

DEDICATED TRANSMISSION
MEASURING SYSTEM
OPERATION AND MAINTENANCE
MANUAL

GENERAL ELECTRIC
INSTRUMENTATION & COMMUNICATION
1200 KONA DRIVE
COMPTON, CA 90220
(213) 642-5317



930 East Meadow Drive
Palo Alto, California 94303
Telephone: (415) ~~494-8666~~
TWX: 910-373-1156

969-6500

969-6500

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Customer Service Dept., Telephone Test Instruments

Telephone: (415) ~~494-6666~~ TWX: 910-373-1156

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SECTION I

GENERAL INFORMATION

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1. SYSTEM DESCRIPTION

1.01 INTRODUCTION

This section contains general information for the WILTRON Dedicated Transmission Measuring System (DTMS). Included is a list of the measurement functions available, special features of the system, possible system configurations, and measurement and display options. Sections II through VII are individual sections for each measurement function which contain a general description, operating procedures, performance verification/calibration, and maintenance instructions. Sections VIII through X

describe the Common Measurement Equipment. The sections are organized as follows:

MEASUREMENT FUNCTIONS

SECTION II	Level/Noise Measurement Function (North American Standards)
SECTION IIA	Level/Noise Measurement Function (CCITT Standards)
SECTION III	Frequency Measurement Function
SECTION IV	Oscillator Measurement Function
SECTION V	Echo Return Loss and Singing Point Measurement Function
SECTION VI	Not Assigned.
SECTION VII	Multimeter Cable Analyzer Measurement Function

COMMON MEASUREMENT EQUIPMENT

SECTION VIII	Model 9104 Timer Module
SECTION IX	Model 9113 -48V Power Supply
SECTION X	Model 9115 AC Power Supply
SECTION XI	Model 9340 Test Selector Panel

NOTE

Sections may be included only for those measurement functions and common measurement equipment that are supplied with the particular system.

1.02 GENERAL DESCRIPTION

The WILTRON DTMS is a complete test facility designed for use in all classes of telephone offices. The system is used for making measurements such as level, noise, frequency, return loss, voltage, current, resistance and capacitance. The measurement functions are available in various combinations to suit the requirements of a particular office. All of the possible measurement function combinations are described in paragraph 1.06. The DTMS replaces the following types of general test sets (both portable and rack mounted) and specific Western Electric KS instruments:

General Test Sets Replaced by the DTMS

Transmission Level Measuring Sets

Transmission Measuring Sets (Level plus oscillator)

Frequency Counters and Meters
100 Hz - 20 kHz)

Noise Measuring Sets (weighted for message noise in dBrn for North American standards or Psophometrically weighted for CCITT standards)

Audio Oscillators (100 Hz - 20 kHz)

Echo Return Loss and Singing Point Setups

AC/DC Voltmeters, Milliammeters, Ohmmeters, Capacitance Bridges

Western Electric Instruments

3A, 3C Noise Measuring Set

21A, 22A and 23A Transmission Measuring Sets

23B Oscillator

27A and B, C and D.

201B Noise Generator

2D Singing Point Test Set

(The WILTRON DTMS can also be used to add measurement functions to an existing 40B or KS20805 installation).

1.03 MEASUREMENT FUNCTIONS AVAILABLE

The DTMS can be supplied with the following measurement functions:

Level/Noise

Frequency

Oscillator

Return Loss

Multimeter Cable Analyzer

Voltage: ac and dc volts

Current: dc milliamperes

Resistance: kilohms and megohms

Capacitance: microfarads

A general description and specifications for each measurement function are provided in the appropriate section of the manual (see paragraph 1.01).

1.04 SPECIAL FEATURES

The DTMS incorporates certain features that greatly simplify operation and reduce the possibility of measurement errors. The control panels provide push-button selection of each test mode for ease

of operation. The selected pushbutton is backlighted to clearly show the test mode in use. Digital displays with large, easy-to-read numerals provide a direct readout of the measured value. Autoranging is used for all measurement functions, thereby relieving the craftsman from range switching when making measurements. In addition, the rapid display update rate allows the craftsman to instantly see the effect of making an adjustment.

1.05 SYSTEM CONFIGURATION

In general, the DTMS consists of one or more test locations connected to the Common Measurement Equipment (which can be located up to 250 feet away). The test location(s) can be equipped with Control Panels and Displays for the required measuring functions as shown in Figure 1-1. The WILTRON Control Panels can be supplied with any one of the commonly used types of test jacks such as Western Electric Types 310 and 309, and Siemens Type 9 Rel K11 6a. Alternatively, access can be through a customer-supplied jack panel or test board. The Common Measurement Equipment (shown in Figure 1-2) consists of a rack-mounted Equipment Shelf which houses the Power Supply, Timer Module, and the Measuring Modules for the required measurement functions. Various combinations of measurement functions are described in paragraph 1.06. All input and output connections to the Control Panels, Displays, and Common Measurement Equipment are made at wire wrap terminals at the rear of the units (see Figure 1-3).

1.06 MEASUREMENT AND DISPLAY OPTIONS

The DTMS is available in a variety of measurement function combinations to meet all telephone office test requirements. The desired measurement functions are selected by choosing the appropriate Control Panels, Displays, and Measuring Modules. Figure 1-1 shows the various Control Panels and Displays available for a typical configuration. Figure 1-4 is a loading chart that illustrates which Mea-

suring Modules may be installed in the Equipment Shelf for the measuring functions required. Measurement and Display options that apply to all measurement functions are described below. Options for individual measurement functions are described in the section of the manual for the function.

(A) Calibration Offset

The DTMS Measuring Modules provide up to 2 dB calibration offset adjustment. While there is no signal loss between the WILTRON Equipment Shelf and Control Panels (because the measuring equipment always works in a bridging mode), unequal losses may exist on cable runs between the measurement point in the office and the WILTRON Control Panels at the test location(s). The calibration offset may be used to compensate for unequal cable run losses by adjusting for a correct reading on the cable run with the highest loss. The remaining cable runs can then be padded out as necessary at the Control Panels to obtain a correct reading at each Display Housing as per existing standard practice.

(B) TP2 Test Boards

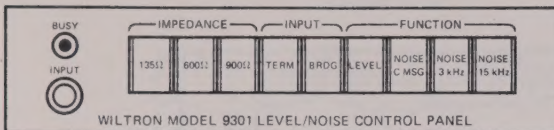
If all measurements are being made at TP2 Test points with the DTMS, the calibration offset described above can be used to correct the reading instead of using TP2 pads.

1.07 INSTALLATION PLANNING

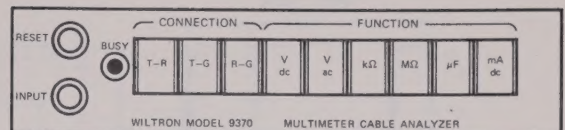
Installation data for the DTMS is provided in a separate package. Refer to the DTMS Engineering Information Manual for further details.

1.08 SYSTEM MAINTENANCE

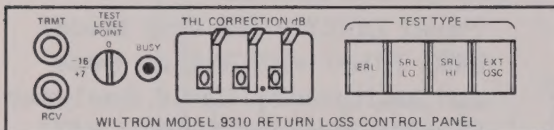
Recommended maintenance intervals for WILTRON DTMS systems is once every 12 months, or when a malfunction is suspected. If any calibration errors are noted, first phone WILTRON at (415) 494-6666. Do not make adjustments on any of the Measurement Modules in the Equipment Shelf unless the test equipment that is being used is known to be accurate.



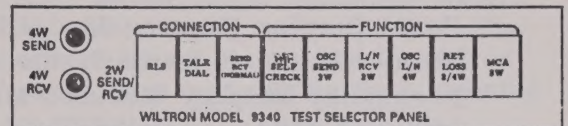
**Level/Noise (and Frequency)
Control Panel Model 9301
(for North American Standards).**



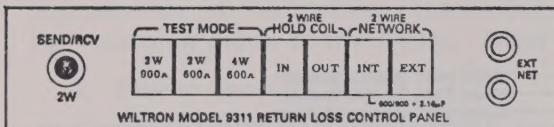
**Multimeter Cable Analyzer
Control Panel Model 9370.**



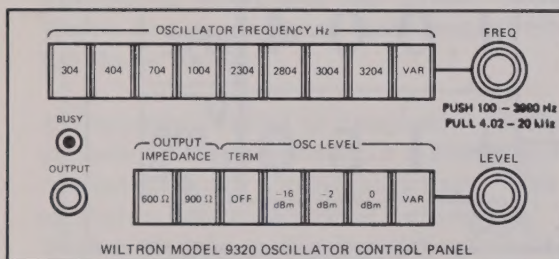
**Return Loss Control Panel
Model 9310**



**Test Selector Panel
Model 9340**



**Return Loss Control Panel
Model 9311**

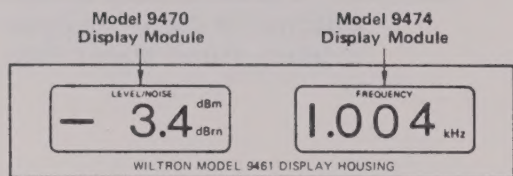


**Oscillator Control Panel
Model 9320**

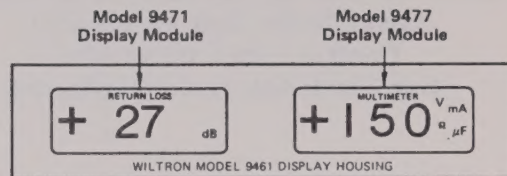
NOTES:

1. Each panel (except oscillator) is 1-3/4" x 7-3/4", thus can replace a standard half jack panel 2 jacks high such as the Western Electric Type 3CL or Type 17 jack strip, etc. Panels can be mounted directly against one another, or using adapter hardware for 19", 23", or 30-1/2" racks.
2. All input and output connections are brought out on wire wrap terminals at the rear of the panels.
3. Alternate Control Panels are available which use Siemens telephone connectors, (Type 9 Rel K11 6a) instead of the Western Electric Type 309/310 jacks.

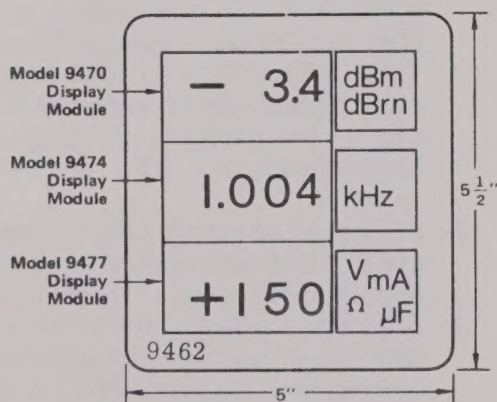
**Figure 1-1a. Control Panels and Displays,
Typical Configuration**



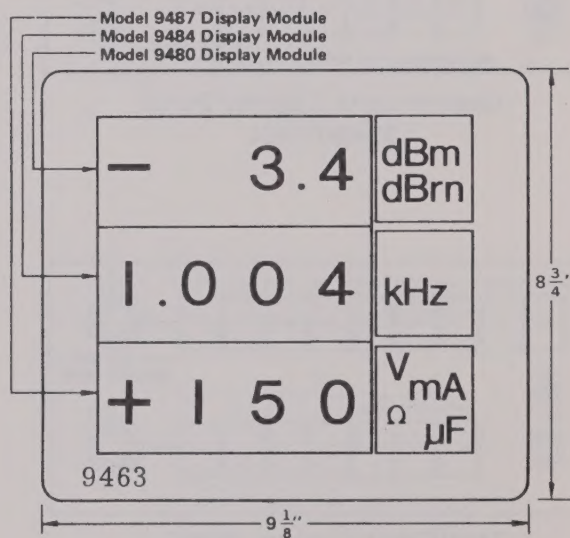
Panel Display Housing Model 9461 fitted with small Level/Noise and Frequency Display Modules Models 9470 and 9474.



Panel Display Housing Model 9461 fitted with Return Loss and Multimeter Cable Analyzer Display Modules Models 9471 and 9477.



Close View Display Housing Model 9462 with small Level/Noise, Frequency and Multi-meter Cable Analyzer Display Modules.



Distant View Display Housing Model 9463 with large Level/Noise, Frequency and Multimeter Cable Analyzer Display Modules.

Figure 1-1b. Control Panels and Displays, Typical Configuration

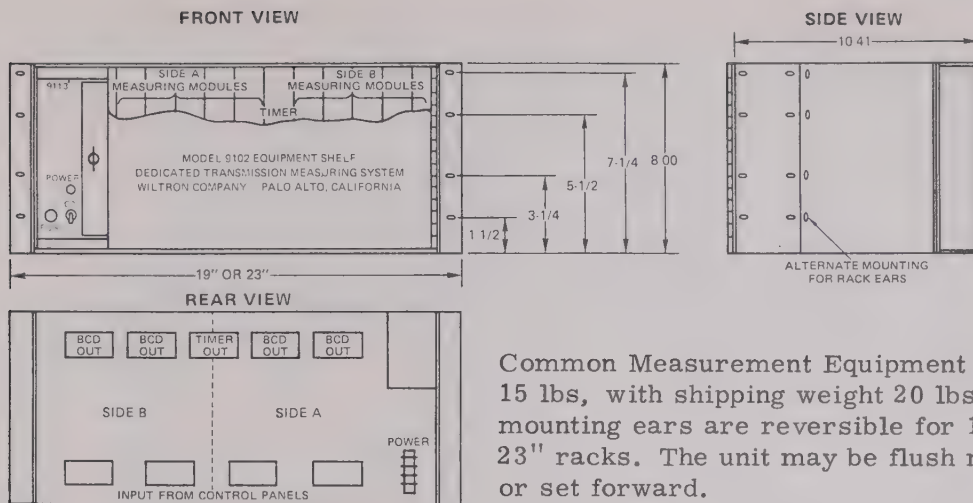


Figure 1-2. Common Measurement Equipment

The maintenance information included in this section of the manual relates only to the common parts of the DTMS. They are:

1. Power Supply Checks
2. Pushbutton Lamp and Label Replacement
3. Replacement of Fuse in Display Housing

Other common parts of the DTMS are the Equipment Shelf and the Timer Module. There are no operator maintenance checks for these parts.

An extender board is supplied with the system to allow access to a PC Board connector when troubleshooting. The extender board is stored behind the Timer Module in the Equipment Shelf.

(A) Power Supply Checks

The +5V, +15V, and -15V outputs from the power supply must be tested to be within limits before any other checks are made for individual measurement functions. An accurate dc voltmeter (such as the Fluke 871A or equivalent) is required for these checks. Following are the procedures for making power supply checks.

NOTE

All adjustments have been carefully set at the factory prior to shipping of the equipment. Do not make any adjustments without first checking to see if the values are within the limits stated in the following procedures.

(B) Replacement of Pushbutton Labels and Lamps

The labels and back-lighting lamps in the Control Panel pushbutton switches can be replaced using the procedure on page 1-10.

(C) Replacement of Fuse in Display Housing

Replace the fuse in the small or large display housing as described in the procedure on page 1-10.

Control Panel Configuration

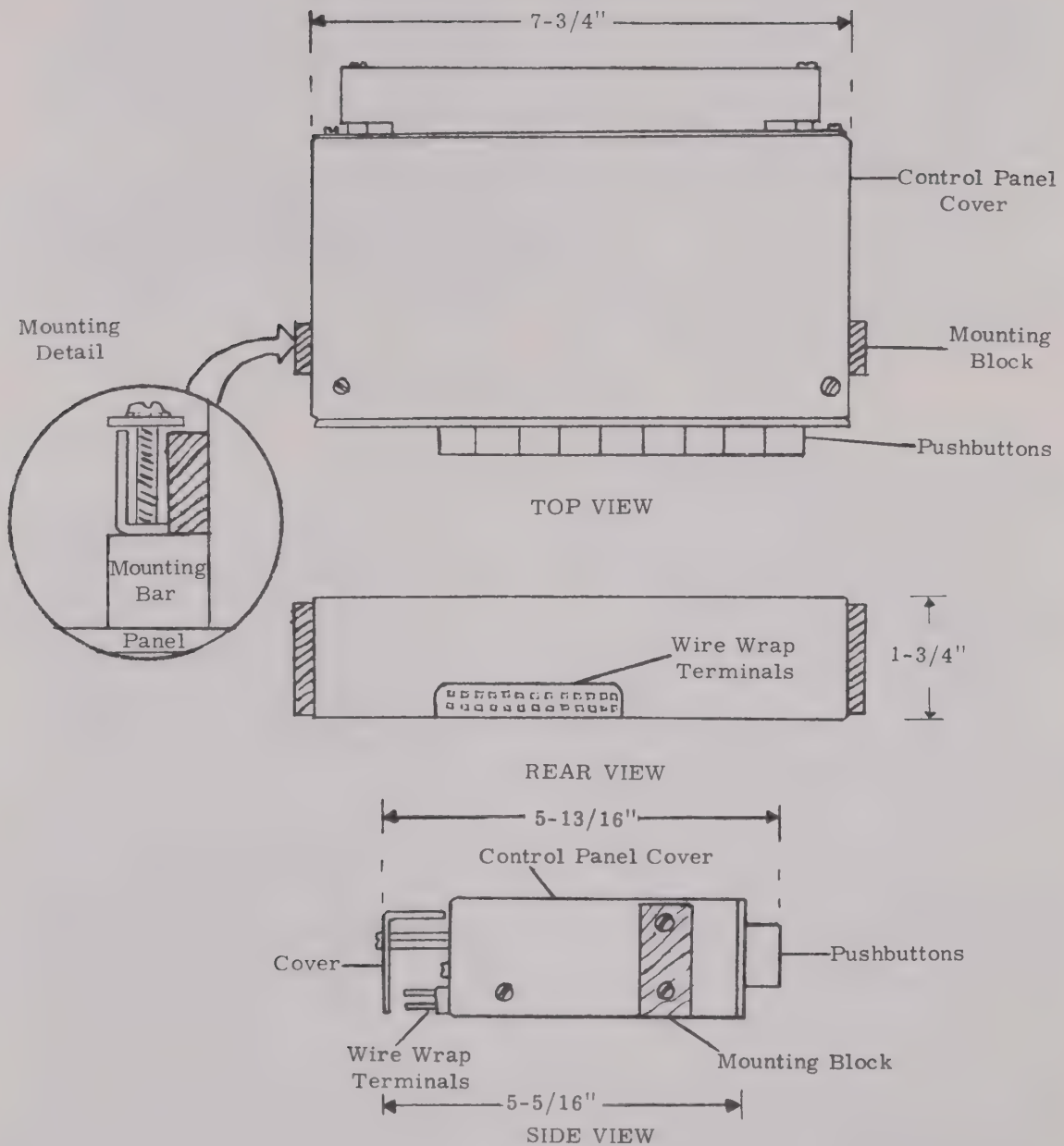


Figure 1-3. Typical Control Panel Configuration
(Model 9301 shown)

DTMS

EQUIPMENT SHELF MEASURING MODULE LOADING OPTIONS

PC BOARD SLOTS IN SIDE A					AND/OR	PC BOARD SLOTS IN SIDE B				
1A	2A	3A	4A	5A	TIMER 9104	1B	2B	3B	4B	5B
POWER SUPPLY 9113										
X	Level/Noise 9200-1 9200-2 9200-3 (9202-1) (9202-2) (9202-3)	OR	Freq. 9240	Osc. 9220	X	Level/Noise 9200-1 9200-2 9200-3 (9202-1) (9202-2) (9202-3)	OR	Freq. 9240	Osc. 9220	OR
	Return Loss 9210-1 9210-2 9210-3		Multimeter 9270-1 9270-2			Return Loss 9210-1 9210-2 9210-3		Multimeter 9270-1 9270-2		

NOTE: Model numbers shown in parentheses are for equipment meeting CCITT Standards.

Figure 1-4. Equipment Shelf (Front View) Showing Possible Locations of Measuring Modules.

POWER SUPPLY CHECKS

STEP	PROCEDURE						
1	Turn on the system power and allow the equipment to warm up for approximately 30 minutes.						
2	Connect the dc voltmeter (Fluke 871A or equivalent) to the -15V TEST and GND. test points on the power supply.						
3	Adjust the dc voltmeter controls as follows: <table> <tr> <td>RANGE</td><td>100</td></tr> <tr> <td>NULL</td><td>.1</td></tr> <tr> <td>Digits setting</td><td>-15.000</td></tr> </table>	RANGE	100	NULL	.1	Digits setting	-15.000
RANGE	100						
NULL	.1						
Digits setting	-15.000						
4	Check that the voltage reading is $-15.000 \pm 75\text{mV}$. If the reading is not within this tolerance, carefully adjust the -15V ADJ. control.						
5	Transfer the dc voltmeter to the +15V TEST and GND. test points on the power supply.						
6	Set the voltmeter digits to +15.000. Check that the reading is $+15.000 \pm 75\text{mV}$. If the reading is not within tolerance, carefully adjust the +15V ADJ. control.						
7	Transfer the dc voltmeter to the +5V TEST and GND. test points.						
8	Set the voltmeter RANGE control to 10, and the digits to +5.000.						
9	Check that the voltmeter reading is $+5.000 \pm 50\text{mV}$. If the reading is not within tolerance, carefully adjust the +5V ADJ. control.						
10	Disconnect the dc voltmeter.						

REPLACEMENT OF PUSHBUTTON LABELS AND LAMPS

STEP	PROCEDURE
1	Turn the system power off at the Equipment Shelf.
2	Insert a screwdriver blade in the slot at the bottom and just behind the pushbutton plastic window.
3	Twist the screwdriver to snap out the plastic window and then remove the label.
4	If the lamp is being replaced, use a 2-inch length of vinyl tubing (1/4 inch diameter) as an extraction tool to remove the lamp. Pull the lamp directly outward.
5	Insert the new lamp (Sylvania Type 24ESB or equivalent) in the socket and ensure it is pushed in all the way.
6	Place the label in front of the lamp and then snap the plastic window in place.
7	Turn the system power on.

REPLACEMENT OF FUSE IN DISPLAY HOUSING

STEP	PROCEDURE
1	Set the power switch on the Power Supply in the Equipment Shelf to the off position.
2	Remove four screws to detach the cover from the Display Housing.
3	Unplug the top PC Board in the Display Housing.
4	Remove the fuse from the fuse clip, then install the new fuse.
5	Install the PC Board in the Display Housing.
6	Secure the cover to the Display Housing using four screws.
7	Set the power switch to ON.

SECTION II

LEVEL/NOISE MEASUREMENT FUNCTION
(NORTH AMERICAN STANDARDS)

SECTION II	CONTENTS	PAGE	SECTION II	CONTENTS	PAGE
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	(A) Customer-Furnished Control Panel	2-1	2.08	FUNCTIONAL BLOCK DIAGRAM	2-16
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	(C) Notched Noise Measurements	2-2			
	(D) Noise-to-Ground Measurements	2-3	2.	GENERAL	
	(E) Notched Noise and Noise-to-Ground Measurements	2-4	2.01	DESCRIPTION OF FUNCTION	
2.02	OPERATING PROCEDURES.....	2-5		The Level and Noise measurement functions share the same Control Panel and Display Module. Front panel push- buttons are provided for selection of im- pedance (135, 600 or 900 ohms), and type of input connection (terminated or bridging) for either Level or Noise measurements. Pushbuttons are also provided for individ- ual selection of up to three Noise filters ("C" Message, 3 kHz Flat, or 15 kHz Flat). A Program filter is available as an option.	
	(A) Function of Controls, Indicators, and Connectors.....	2-5		Other Control Panels are available that provide additional measurement functions such as notched noise and noise-to-ground. These Control Panels are described in Paragraphs 2.01(C) through 2.01(E).	
	(B) Level/Noise Display ...	2-6		Measurements are made at the front panel INPUT jack or through customer-furnished equipment described in paragraphs 2.01(A) and 2.01(B) following. The Level/Noise Measurement Module consists of three plug- in PC boards (Models 9200-1, 9200-2 and 9200-3) installed in the Equipment Shelf in addition to the Timer Module (Model 9104). Specifications for the Level/Noise measure- ment function are provided in Table 2-1.	
	(C) Level/Noise Opera- tional Check	2-6			
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(A) Customer-Furnished Control Panel

The Level/Noise measuring equipment can also be used through a customer-furnished test panel having a jack for the test signal input and an indicator lamp for BUSY status. In this case, the WILTRON Level/Noise Control Panel is not used, and impedance, type of connection, and noise filter selection are made by strapping connections on the mother board in the Equipment Shelf.

(B) Customer-Furnished Jack and Lamp Multiples

If desired, the WILTRON Level/Noise Control Panel can be used in conjunction with one or more customer-furnished multiple jack and lamp locations. The desired number of test jacks are connected in parallel with the Level/Noise Control Panel INPUT jack connections through the wire wrap terminals at the rear of the panel. The lamps can be wired to provide a BUSY indication at all test locations except the one in use.

All of the above options are described in the WILTRON DTMS Installation Manual. Refer to the AW drawings for exact detail.

(C) Notched Noise Measurements

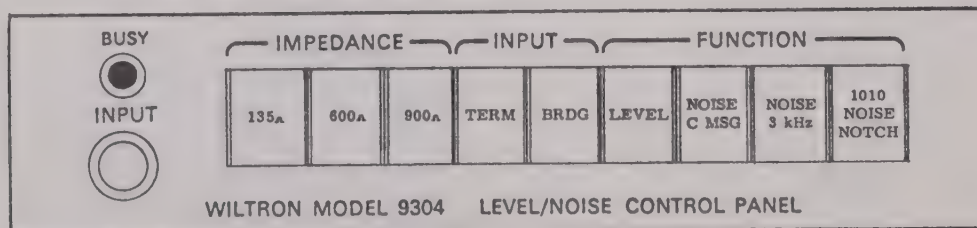
The Model 9304 Level/Noise Control Panel is similar to the standard Level/Noise Control Panel (Model 9301), except that it allows notched noise measurements to be made.

Notched noise measurements are made when a holding tone (usually 1004 or 1010 Hz) is applied at the far end of the trunk under test, and is then notched out at the near end to obtain a dynamic noise reading. The holding tone is applied to the trunk under test to maintain normal in-use noise conditions on the trunk. The holding tone causes possible noise sources such as digital to analog converters and companions in the trunk circuit to operate as if a normal signal is being transmitted.

The holding tone is notched out at the near end using a sharp bandstop filter. The filter attenuates holding tones between 995 and 1025 Hz by more than 50 dB. Thus, the presence of the holding tone does not add to the noise reading, but does ensure normal trunk circuit operating conditions. This enables noise measurements on companded trunks or PCM "T" carrier channels. The noise measured includes harmonic distortion and quantizing noise effects.

The notched noise filter is used in conjunction with the C message or the 3 kHz flat noise filter, as desired. Notched noise measurements can be made over a range of 0 to 62 dBm, with holding tone inputs to the Control Panel of up to 0 dBm.

For example, if a holding tone is applied at the far end of the circuit at a -16 dB point and is -10 or -13 dB below the test tone (holding tone -26 or -28 dBm), it is received at the near end at a +7 dB point at -3 or -6 dBm and is then notched out. The dynamic noise can then be measured.



Level/Noise Control Panel Model 9304

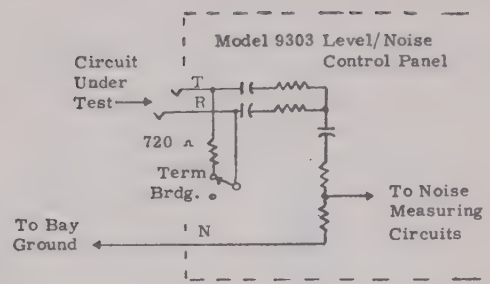
If the local milliwatt supply is connected directly to the notched noise input, the reading should be less than +40 dBrn if the milliwatt has low distortion and noise.

The 1010 NOISE NOTCH pushbutton is pressed along with either the C MSG NOISE pushbutton or the 3 kHz NOISE pushbutton when notched noise measurements are being made. The 1010 NOISE NOTCH pushbutton is a press-to-select/press-to-release type, and lights only when either of the noise filters is selected.

Notched noise measurements can be made with a steady tone applied at the far end of the trunk under test. Measurements can also be made from a modified quiet termination at the far end that alternates approximately every 30 seconds between a quiet termination and a tone. This permits both level and notched noise measurements to be made by simply pressing the appropriate pushbuttons on the Model 9304 Control Panel. The C MSG or 3 kHz NOISE pushbutton is pressed when the quiet termination is applied to measure noise pick-up on the circuit. When the tone comes on, the LEVEL pushbutton is pressed to measure the circuit loss; then the 1010 NOISE NOTCH pushbutton is pressed to measure dynamic noise.

(D) Noise-to-Ground Measurements

Level/Noise Control Panel Model 9303 includes the capability of making noise-to-ground measurements. The noise is measured from Tip-Ring to bay or frame ground as shown in the simplified diagram below. Note that this measurement configuration is the same as that used in the W.E.Co. 3C Noise Meter.

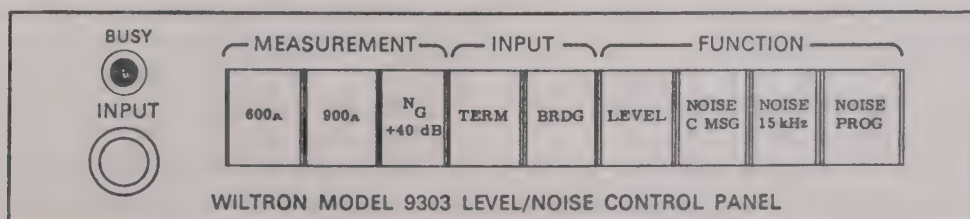


Model 9303 Level/Noise Control Panel

During installation, it is important that the black wire from terminal N at the rear of the Control Panel is connected to bay or frame ground. The noise-to-ground measurement is relative to this ground point.

Noise-to-ground measurements are made with the NG + 40 dB pushbutton and either the "C" Message or 3 kHz Flat pushbutton selected. The approximate level of 60 Hz noise on the circuit can be determined by first measuring the noise-to-ground with the "C" Message filter selected and then with the 3 kHz Flat filter selected. The difference between the two noise levels is largely due to the amount of 60 Hz noise on the circuit.

The noise-to-ground reading is the display reading plus 40 dB. For noise levels higher than +102 dBrn (+62 dBrn on display plus 40 dB), the display digits are blanked and a + sign is displayed. If desired, the noise level in dBm (unweighted) can be read by pressing both the NG + 40 dB and the LEVEL pushbuttons, thus permitting noise measurements up to +50 dBm (equivalent to +140 dBrn) to be made.

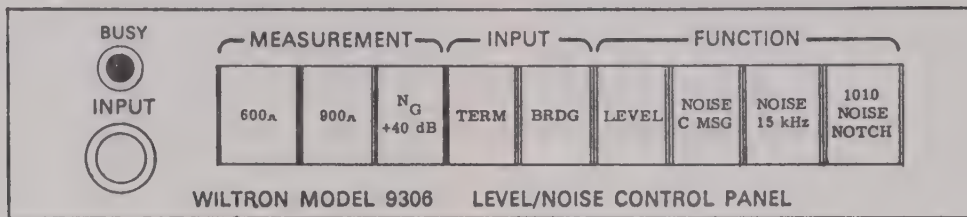


Model 9303 Level/Noise Control Panel

(E) Notched Noise and Noise-to-Ground Measurements

Both the notched noise and the noise-to-

ground measurement functions are available in a single Level/Noise Control Panel, Model 9306. The pushbutton layout for this panel is shown below.



Model 9306 Level/Noise Control Panel

Table 2-1. Specifications for Level/Noise Measuring Function

LEVEL

AUTORANGING: from -52 dBm to +10 dBm, digital reading in 0.1 dB steps.

ACCURACY: <±0.1 dBm.

VARIATION WITH FREQUENCY: <±0.1 dB, 100 Hz to 20 kHz.

VARIATION WITH TEMPERATURE: <±0.002 dB/°C.

DETECTOR LAW: Full wave average.

READING UPDATE RATE: 9 times per second.

NOISE

AUTORANGING: from 0 to 62 dBm, digital reading in 1 dB steps.

ACCURACY: <±1 dB.

VARIATION WITH TEMPERATURE: <±0.02 dB/°C from 0 to 50° C.

DETECTOR LAW: Quasi-rms.

NOISE FILTERS: Selected by customer. "C" Message, 3 kHz Flat, 15 kHz Flat or Program. Filters all meet Bell System Reference PUB41009.

READING UPDATE RATE: 2-1/4 times per second.

LEVEL AND NOISE

REMOTE SELECTION: Level or Noise measurement.

AUTOMATIC BLANKING of display digits when the input level is out of range. A + sign is displayed for overrange and a - sign for under-range.

SELECTABLE INPUT IMPEDANCE: 135 ohm, 600 ohm, 900 ohm, terminated or bridging.

INPUT RETURN LOSS: >30 dB for 600 or 900 ohms.

BRIDGING IMPEDANCE: 100 kilohms.

READOUT RESPONSE DYNAMICS are similar to analog meters.

DIGITAL READOUT is derived by rounding off a more precise measurement.

THE ROUND-OFF LAW is that all half-digits or over are raised to the next whole digit.

A MONITORING OUTPUT is provided for use with a loudspeaker or phones. See paragraph 2.02(E) note.

LONGITUDINAL BALANCE: >60 dB from 50 Hz to 6 kHz.

LONGITUDINAL VOLTAGE PROTECTION: up to 200V rms at 60 Hz.

DC BLOCKING ON BRIDGING CONNECTIONS: up to ± 300 V dc.

TRANSIENT VOLTAGE PROTECTION: up to 600V having 10 microsecond rise time and 1200 microsecond decay time across input terminals.

2.02 OPERATING PROCEDURES

(A) Function of Controls, Indicators, and Connectors

Table 2-2 describes the function of the controls, indicators, and connectors on the Level/Noise Control Panel.

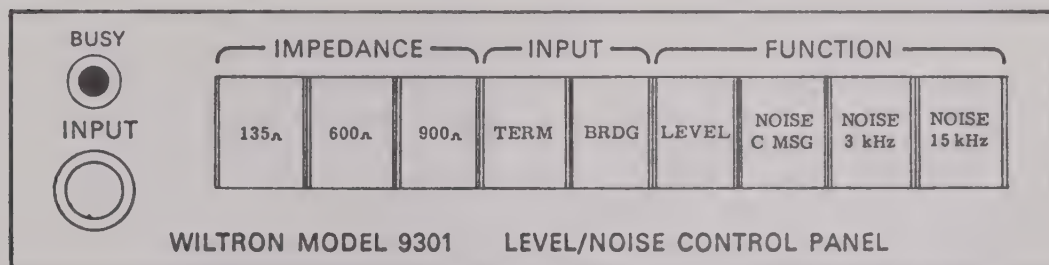


Figure 2-1. Level/Noise Control Panel

Table 2-2. Function of Controls, Indicators, and Connectors

BUSY: Light emitting diode indicator lamp. When indicator is not lit the Level/Noise measurement function is available for use. The indicator is lit only when the Level/Noise measurement equipment is being used by a test location multiple.

INPUT: Western Electric Type 310 telephone jack (Type 309 optional) connected tip and ring. Sleeve is floating to permit sleeve conditioning or holding. Inserting a plug in the jack provides access to the Level/Noise and Frequency measurement equipment if BUSY indicator is not lit. See paragraphs 2.01(A) and 2.01(B) for input options.

IMPEDANCE: Three back-lighted pushbutton switches used to select the proper impedance (135, 600, or 900 ohms) for the circuit under test. The impedance selected can be either a terminating or bridging connection as selected by the INPUT switch group. See the note following this table.

INPUT: Two back-lighted pushbutton switches. Provide selection of either a Terminating or Bridging connection to the circuit under test and at the impedance selected by the IMPEDANCE switch group. For Terminating connections at 600 or 900 ohms impedance, supervision is provided from the Level/Noise Control Panel for making measurements on 2-wire Outgoing Trunks. No

supervision is provided by the Control Panel for Bridging connections. Refer to paragraph 2.02(F). See note below.

FUNCTION: Four back-lighted pushbutton switches. Select either the Level or Noise measurement function, with choice of one of three weighting filters for Noise measurement. Selection of impedance and input connection (bridging or terminating) for the Level or Noise measurement is made at the IMPEDANCE and INPUT switch groups.

NOTE

One pushbutton of each group (IMPEDANCE, INPUT, and FUNCTION) must always be selected to obtain accurate readings.

(B) Level/Noise Display

The Level/Noise display (see Figure 2-2) is a digital display used in conjunction with the Level/Noise Control Panel. It displays signal levels from -52 to +10 dB with 0.1 dB accuracy, and noise levels from 0 to 62 dBrn with 1 dB accuracy. Digits are blanked for overrange or underrange input signal levels. A + sign is displayed for overrange and a - sign for underrange.



Figure 2-2. Level/Noise Display

(C) Level/Noise Operational Check

The operational check procedure should be performed periodically to ensure that the Level/Noise measurement function is in working order.

(D) Level Measurements

Level measurements are normally made at a zero transmission or test level point

(OTLP). If desired, the Level and Noise measurement modules can be offset up to ± 2 dB for use at TP2 points. Refer to paragraph 1.06 in Section I of the manual. The input impedance for Level or noise measurements can be 135, 600, or 900 ohms with either a terminating or bridging connection. The Level Display digits are blanked when the test signal level is above or below the Level measurement limits. The optional Interference Protection Filter (WILTRON Model 9131) is used with the Level measurement equipment to restrict the frequency range. However, the filter allows an accurate measurement of signal levels inside the frequency range of 100 Hz to 15 kHz.

(E) Noise Measurements

Noise measurements are usually made using a 'C' Message, 3 kHz Flat, or 15 kHz Flat filter. The appropriate filter is selected by pushbutton controls on the Level/Noise Control Panel. A Program filter may be installed in place of the 'C' Message, 3 kHz Flat, or 15 kHz Flat filter. Selection of input impedance and input connections is the same as described for Level Measurements above.

NOTE

A 900 ohm audio monitor for the Level and Noise measurement functions is provided for both Side A and Side B of the Equipment Shelf. The monitor output is connected to a customer-supplied jack from two wire wrap terminals at the rear of the Equipment Shelf. Refer to Figure 2-8 for the location of the terminals. The audio monitor output level ranges are as follows:

Level: approximately -10 dBm to -20 dBm.

Noise: approximately 0 dBm to -10 dBm.

(F) Circuit Holding

When the TERM pushbutton is selected on the Level/Noise Control Panel, a resistor (135, 600, or 900 ohms, as selected) is connected to the tip and ring contacts of the INPUT jack. The 600 and 900 ohm resistors are of sufficient wattage rating to permit the application of 48V for offhook supervision on 2-wire Trunks. The 600 or 900 ohm resistor provides the path for the dc loop current. When a Bridging connection is selected, a dc loop path is not provided from the Level/Noise Control Panel.

CAUTION

Do not apply 48V to the INPUT jack when a 135 ohm Terminating connection is selected. Otherwise the 135 ohm terminating resistor may be damaged.

The sleeve connection of the Level/Noise Control Panel INPUT jack is floating to permit sleeve holding or conditioning.

OPERATIONAL CHECKS

STEP	PROCEDURE
1	Patch from the OUTPUT jack on the Oscillator Control Panel to the INPUT jack on the Level/Noise Control Panel. * If the system is not equipped with the Oscillator function, substitute the office milliwatt supply (OTLP).
2	Select an Oscillator (or milliwatt supply) output of 1000 Hz, 0 dBm at 600 ohms.
3	Check that the BUSY indicator is not lit on the Level/Noise Control Panel or the Oscillator Control Panel (if used). * Press the 600 Ω , TERM, and LEVEL pushbuttons on the Level/Noise Control Panel.
4	Check that the Level/Noise Display readout is approximately 0 dBm.
5	Remove the patch from the Level/Noise and Oscillator Control Panels.
6	Patch the Oscillator (or milliwatt supply) output to the input of a 600 Ω attenuator with a range of 40 dB (such as provided in the HP353A Patch Panel, or equivalent).
7	Patch the output of the attenuator to the INPUT jack on the Level/Noise Control Panel.
8	Set the attenuator to 40 dB. Press one of the NOISE pushbuttons, then check that the Level/Noise Display readout is approximately +50 dBm. Remove the patch cords.
9	If desired, operational checks on the 900 and 135 ohm positions can be made as above.
	*Measurements may also be made through customer-supplied jacks and switching. Refer to paragraph 2.01(B) for details regarding jack and lamp multiples.

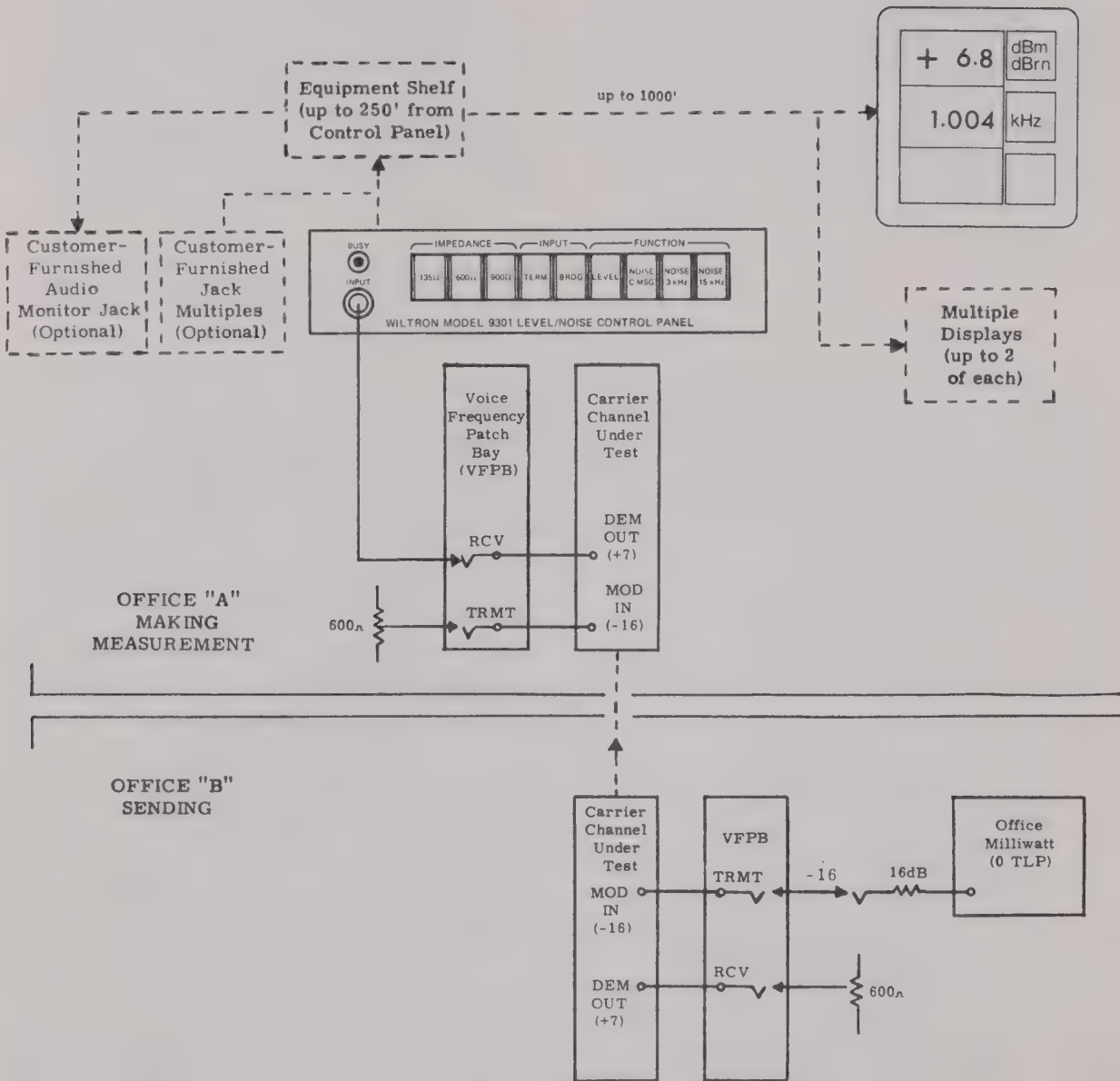


Figure 2-3. Level/Frequency Measurements (4-Wire), Typical Test Setup

(F) Circuit Holding

When the TERM pushbutton is selected on the Level/Noise Control Panel, a resistor (135, 600, or 900 ohms, as selected) is connected to the tip and ring contacts of the INPUT jack. The 600 and 900 ohm resistors are of sufficient wattage rating to permit the application of 48V for offhook supervision on 2-wire Trunks. The 600 or 900 ohm resistor provides the path for the dc loop current. When a Bridging connection is selected, a dc loop path is not provided from the Level/Noise Control Panel.

CAUTION

Do not apply 48V to the INPUT jack when a 135 ohm Terminating connection is selected. Otherwise the 135 ohm terminating resistor may be damaged.

The sleeve connection of the Level/Noise Control Panel INPUT jack is floating to permit sleeve holding or conditioning.

OPERATIONAL CHECKS

STEP	PROCEDURE
1	Patch from the OUTPUT jack on the Oscillator Control Panel to the INPUT jack on the Level/Noise Control Panel. * If the system is not equipped with the Oscillator function, substitute the office milliwatt supply (OTLP).
2	Select an Oscillator (or milliwatt supply) output of 1000 Hz, 0 dBm at 600 ohms.
3	Check that the BUSY indicator is not lit on the Level/Noise Control Panel or the Oscillator Control Panel (if used). * Press the 600 Ω , TERM, and LEVEL pushbuttons on the Level/Noise Control Panel.
4	Check that the Level/Noise Display readout is approximately 0 dBm.
5	Remove the patch from the Level/Noise and Oscillator Control Panels.
6	Patch the Oscillator (or milliwatt supply) output to the input of a 600 Ω attenuator with a range of 40 dB (such as provided in the HP353A Patch Panel, or equivalent).
7	Patch the output of the attenuator to the INPUT jack on the Level/Noise Control Panel.
8	Set the attenuator to 40 dB. Press one of the NOISE pushbuttons, then check that the Level/Noise Display readout is approximately +50 dBm. Remove the patch cords.
9	If desired, operational checks on the 900 and 135 ohm positions can be made as above.
	*Measurements may also be made through customer-supplied jacks and switching. Refer to paragraph 2.01(B) for details regarding jack and lamp multiples.

Level Measurements,
4-Wire

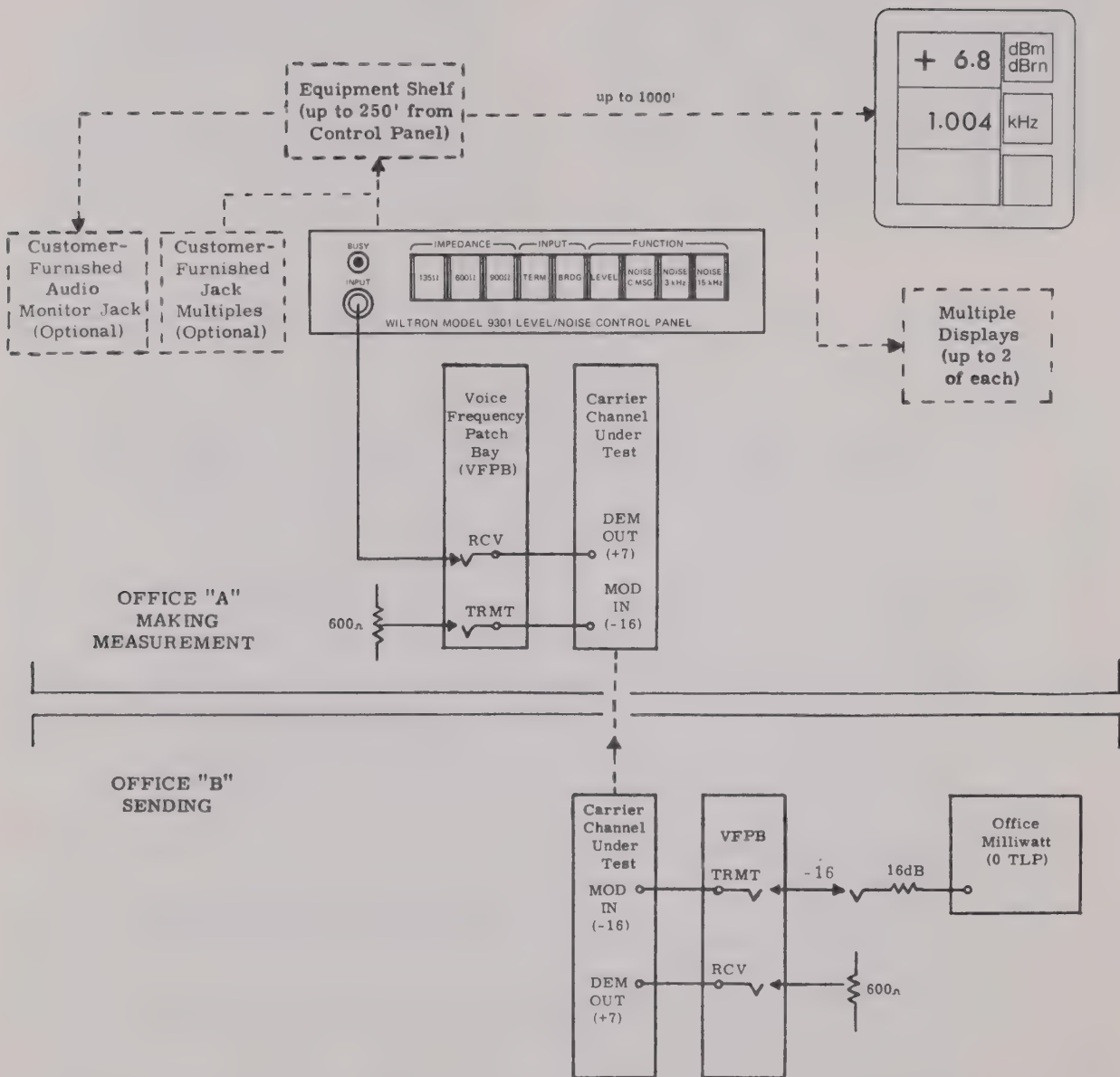


Figure 2-3. Level/Frequency Measurements (4-Wire),
Typical Test Setup

LEVEL/FREQUENCY MEASUREMENTS (4-Wire)

STEP	PROCEDURE
1	Patch the test signal to be measured to the INPUT jack on the Level/Noise Control Panel. * See Figure 2-3 for a typical test setup for 4-wire level/frequency measurements.
2	If the BUSY indicator is lit on the Level/Noise Control Panel, wait until the light goes out. <u>NOTE</u> When the BUSY indicator is lit, the Level/Noise measurement function is being used at a jack multiple.
3	Press the 600Ω, TERM, and LEVEL pushbuttons. * Read the level in dBm on the Level/Noise Module in the Panel Display Housing (or on the Close View or Distant View Display Housing). If the system is equipped with a Frequency Module in the Display Housing, the frequency of the test signal is automatically displayed. <u>NOTE</u> If the test signal level exceeds +10 dBm or is lower than -52 dBm, digit blanking occurs. The - sign on the display is lit when the signal level is lower than -52 dBm, or when no signal input is present. *Measurements may also be made through customer-supplied jack multiples, refer to paragraph 2.01(B) for details.

Level Measurements 1 or 2 Way Trunks

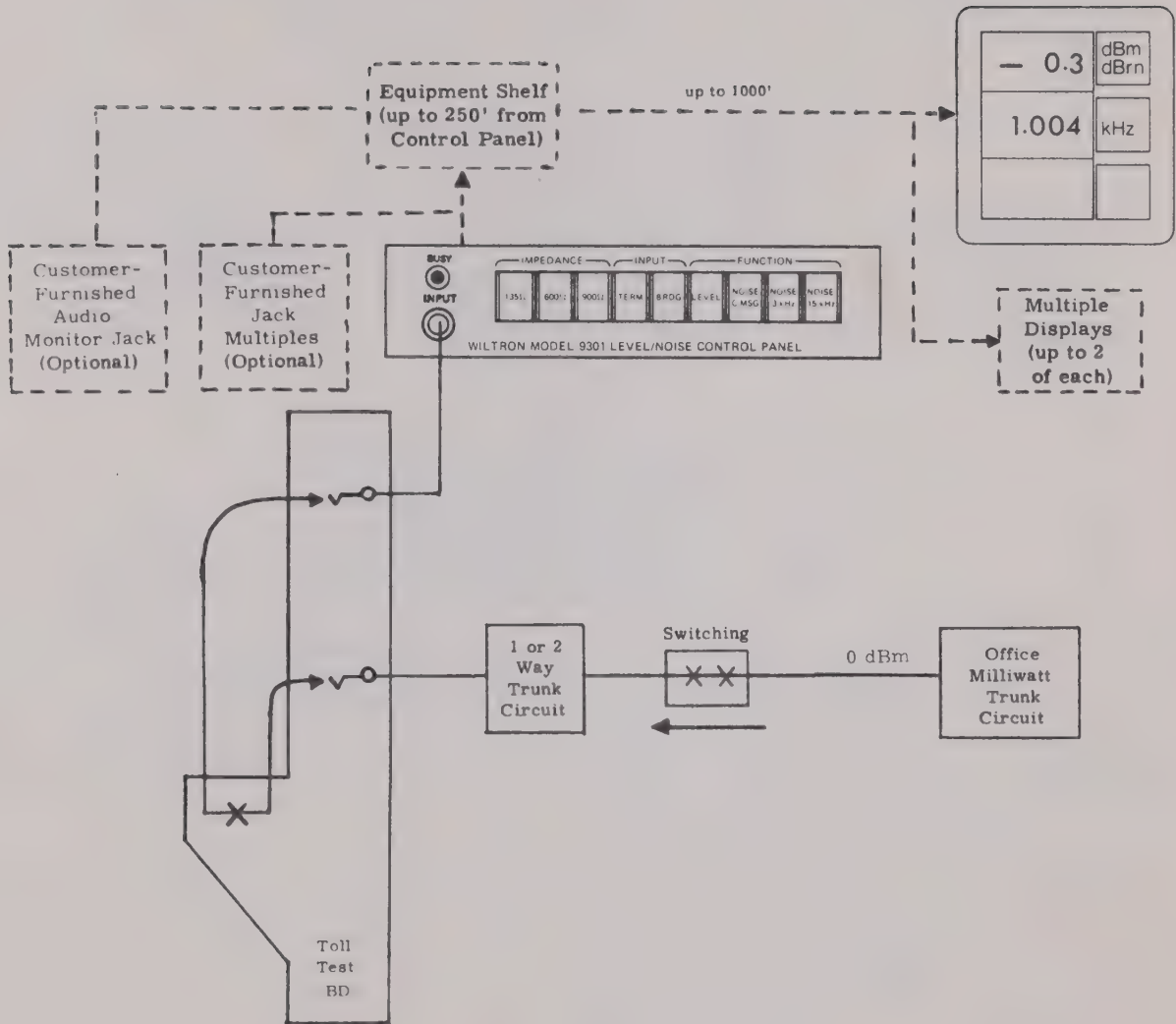


Figure 2-4. Level/Frequency Measurements on 1 or 2 Way Trunk Circuits, Test Setup

LEVEL/FREQUENCY MEASUREMENTS ON 1 OR 2 WAY TRUNK CIRCUITS

STEP	PROCEDURE
1	Connect the test setup as shown in Figure 2-4.
2	If the BUSY indicator is lit on the Level/Noise Control Panel, wait until the light goes out. *
	<u>NOTE</u> When the BUSY indicator is lit, the Level measurement function is being used at a jack multiple.
3	Press the LEVEL pushbutton, the appropriate pushbutton for the IMPEDANCE for the circuit under test (600 or 900 Ω), and the type of INPUT connection (terminating or bridging). *
4	Set up a call on the circuit to be tested to the office milliwatt 1 kHz test number. ** To measure the 1 kHz test signal, read the level in dBm on the Level/Noise Module in the Panel Display Housing, or in the Close View or Distant View Display Housing. If the DTMS system is equipped with a Frequency Module, the frequency of the test signal is automatically displayed. <u>NOTE</u> If the test signal level exceeds +10 dBm or is lower than -52 dBm, digit blanking occurs. The - sign on the display is lit when the signal level is lower than -52 dBm, or when no signal input is present. The + sign is lit when the test signal level is greater than +10 dBm. *Refer to paragraph 2.01(B) for customer-supplied jack multiples. **Refer to paragraph 2.02(F) for circuit holding capability.

Noise Measurements 4-Wire

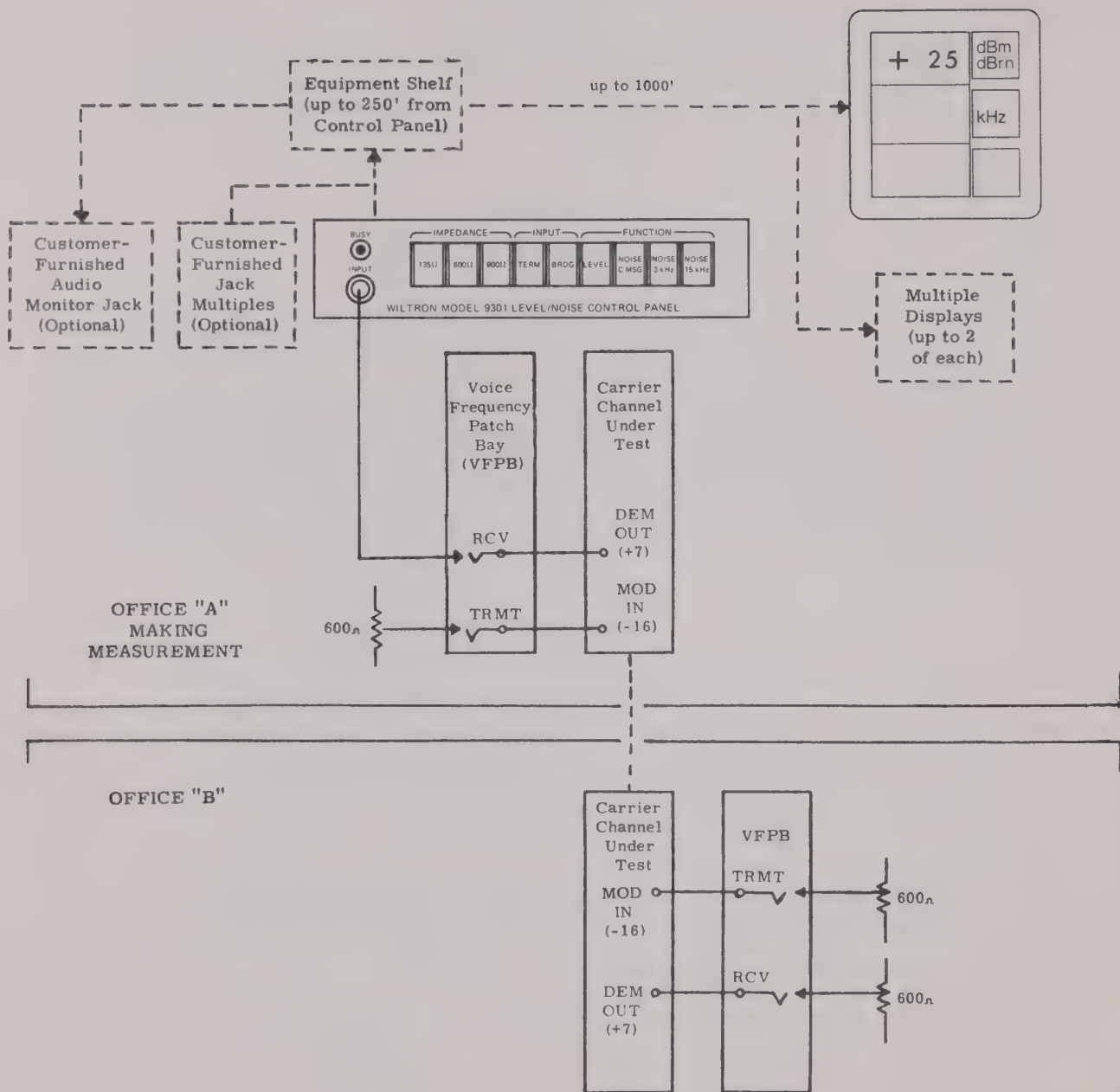


Figure 2-5. Noise Measurement Test Setup, 4-Wire

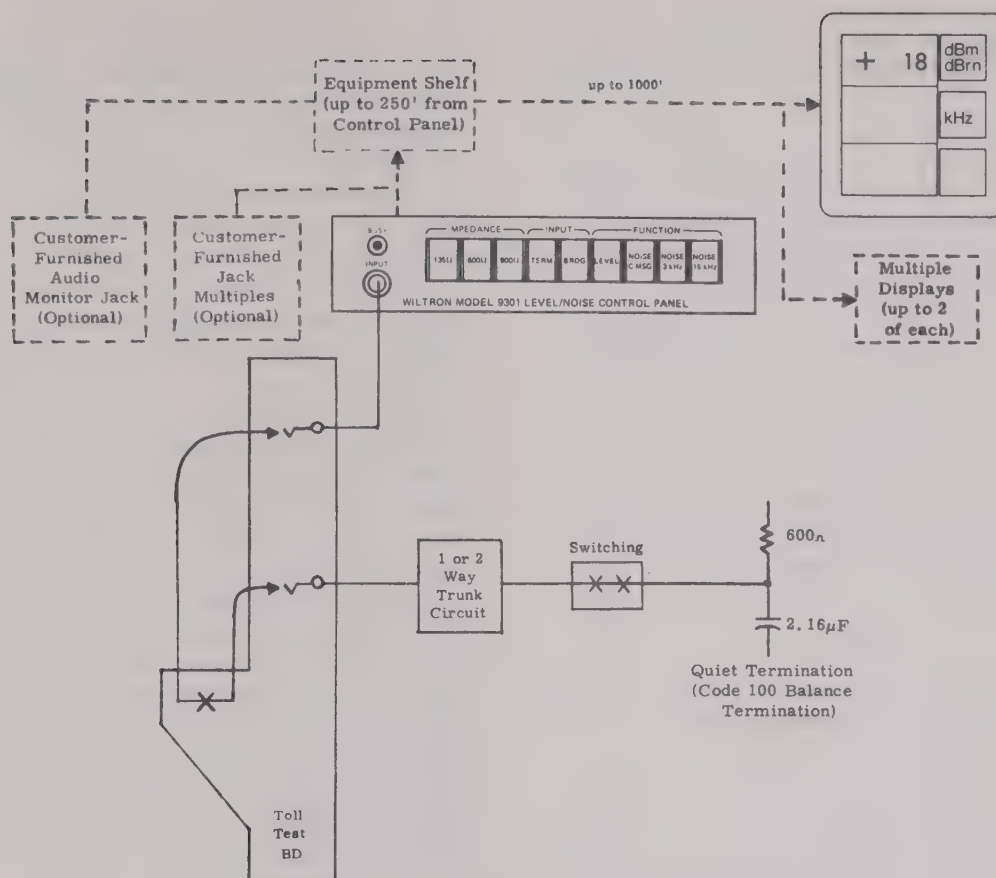


Figure 2-6. Noise Measurement Test Setup, 1 or 2 Way Trunk Circuits

NOISE MEASUREMENT

STEP	PROCEDURE
1	Patch the noise signal to be measured to the INPUT jack on the Level/Noise Control Panel. * See Figure 2-5 for 4-wire noise measurement test setup, or Figure 2-6 for test setup for 1 or 2 way trunk circuits.
2	If the BUSY indicator is lit on the Level/Noise Control Panel, wait until the light goes out. When the BUSY indicator is lit, the Level/Noise measurement function is being used at a jack multiple.
3	Press the NOISE pushbutton having the desired weighting filter. Select the appropriate IMPEDANCE and INPUT pushbuttons. * Read the noise level in dBrn on the Level/Noise panel Display Housing (or on the Close View or Distant View Display Housing). If the system is equipped with a Frequency Module in the Display Housing, the readout will be blanked.
	NOTE: If the noise level exceeds +62 dBrn, digit blanking occurs and only the + sign is lit. If the noise level is less than 0 dBrn, only the - sign is lit.
	*Refer to paragraph 2.01(B) for customer-supplied jack multiples.

2.03 PERFORMANCE VERIFICATION/ CALIBRATION

(A) Introduction

This procedure enables the user to verify that the Level/Frequency measurement function meets the design specifications. The check may be performed upon installation of the equipment (prior to use), periodically, or when failure of the measurement function is suspected. If the proper readings are not obtained, the calibration should be checked and adjusted as necessary before attempting to troubleshoot the equipment. The calibration has been set at the factory to provide a true level reading in dBm (see paragraphs 1.06(B) and 1.06(C) for offset information).

NOTE

Steps 1 through 6 of the procedure are used for checking the calibration upon installation, for calibration offset, or when PC board 9200-3 has been replaced. Steps 7 and 8 of the procedure are used only when PC board 9200-2 is replaced. No calibration readjustments are required if PC board 9200-1 is replaced.

(B) Test Equipment required

Table 2-3 lists the test equipment required for the performance check. Standard telephone patch cords, adapters, and test leads may be used. Equivalent test equipment may be used if the accuracy equals or exceeds that of the equipment listed.

Table 2-3. List of Test Equipment

TRUE RMS VOLTMETER: Fluke 931B

AUDIO OSCILLATOR: HP 236A

FREQUENCY COUNTER: HP 5246L

ATTENUATOR: HP 350D

2.04 THEORY OF OPERATION

Refer to Figure 2-7 at the end of this section. The test signal to be measured is patched to the INPUT jack on the Level/Noise Control Panel. Either a terminating or bridging connection is made to the circuit under test, depending on the selection made. The terminating connection is made at an impedance of 135, 600, or 900 ohms, pushbutton selected. Either the Level or Noise measurement function is selected by front panel pushbutton switches. Pushbutton switches are provided for selecting one of three noise weighting filters. From the Control Panel, the test signal is applied to a balanced amplifier in the Level/Noise Measuring Module located in the Equipment Shelf. The balanced amplifier establishes the required longitudinal balance and high frequency common mode rejection characteristics for the input circuit. The balanced amplifier is followed by a second amplifier which sets the low frequency common mode rejection for the input circuit. The output of the second amplifier is applied to a dual-gain amplifier that is controlled by the Level/Noise selection circuit.

The amplifier gain is made greater when the Noise measurement function is selected, to raise the level of the Noise up to that required by the measuring circuits. The dual-gain amplifier output is fed directly to the autoranging circuits when Level is selected, or through the noise weighting filter when Noise is selected. The autoranging circuits automatically adjust the level of the test signal to be within a 10 dB range for the peak and average detectors.

A gain-selectable amplifier following the autoranging circuits compensates for the change in the test signal level resulting from switching the input impedance of the Level/Noise Control Panel between 135, 600, and 900 ohms terminated or bridging connection.

The output of the gain-selectable amplifier is applied to two detectors. One of the detectors responds to the average value of

the test signal level, and is used for both the Level and Noise measurement functions. The second detector responds to the peak value of the test signal level, and is used to obtain the proper response for Noise measurements. Both detector outputs are applied to a summing and smoothing amplifier which also sets the Level/Noise calibration. The output of the amplifier is a dc voltage with a magnitude proportional to the test signal level over a 10 dB range.

The dc output voltage from the summing and smoothing amplifier is applied to a comparator along with timing signals from the Timer Module to develop a digital signal that contains the test signal level information. The comparator output is processed by gating and sequence detection circuits to obtain the digital signals necessary to drive the counters. The BCD (binary coded decimal) outputs from the counters are decoded by the decoder/drivers located in the Level/Noise Display Module. The outputs from the decoder/drivers cause the appropriate decimal digit to light.

Additional digital logic circuits develop the control signals required to blank the display digits and light the appropriate polarity sign for an underrange or overrange input signal level.

2.05 TROUBLESHOOTING

(A) Level Measurement Function

The troubleshooting chart, Table 2-4, is used to isolate a fault in the Level measurement function. The Signal Flow Chart (Figure 2-8) can be used in conjunction with Table 2-4 to facilitate troubleshooting. The test equipment required is a digital multimeter, WILTRON Model 9270 or equivalent, and a 0 dBm, 1 kHz signal source (WILTRON Model 9320 Oscillator or equivalent).

(B) Noise Measurement Function

Table 2-5 is a troubleshooting chart used to isolate a fault in the Noise Measurement

function. Refer also to the Signal Flow Chart, Figure 2-8. The test equipment required is as follows:

1. Digital Multimeter, WILTRON Model 9270 or equivalent.
2. 0 dBm, 1 kHz signal source, (WILTRON Model 9320 Oscillator or equivalent).
3. Decade Attenuator, General Radio 1450 or equivalent.

2.06 REMOVAL AND REPLACEMENT INSTRUCTIONS

The following procedure is used to remove or replace the PC Board in the Level/Noise Control Panel.

1. Switch the system power off.
2. Remove four screws from the cover, then pull it straight back to detach the cover from the PC board connector inside the Control Panel.
3. Remove the retaining ring which secures the BUSY indicator. Press the indicator backwards to remove it from the front panel.
4. Remove one screw to detach the INPUT jack from the front panel.
5. Remove the PC board and the attached parts from the Control Panel.

NOTE

The BUSY indicator and INPUT jack are hard-wired to the PC board.

6. Install the new PC board in the Control Panel so that the pushbutton switches extend through the front panel.
7. Press the BUSY indicator through the grommet in the front panel and secure it with the retaining ring.
8. Secure the INPUT jack to the front panel with one screw.
9. Install the cover on the Control Panel so that the PC board connector is properly mated with the socket on the cover.

Parts List

10. Secure the cover using four screws.

2.07 PARTS LIST

Table 2-6 lists the WILTRON part numbers for the replaceable assemblies used with the Level/Noise measurement function.

Table 2-6. Parts List for Level/Noise Measurement Function

<u>DESCRIPTION</u>	<u>WILTRON PART NO.</u>
Level/Noise Control Panel (Complete)	9301
Level/Noise Measuring Module	9200
PC Board, Weighting Filters (holds up to 3 filters)	9200-1
Noise Filter, "C" Message	9132
Noise Filter, 3 kHz Flat	9133
Noise Filter, 15 kHz Flat	9134
Program Filter	9135
Protection Filter	9131
PC Board, Analog to Digital Converter	9200-2
PC Board, Level/Noise Receiver	9200-3
Level/Noise Display Module (see note)	9470 or 9480
Display Housing, Panel, Close View, or Distant View (see note)	9461, 9462 or 9463

NOTE: The Model 9470 Level/Noise Display Module is housed in Panel Display Housing Model 9461 or Close View Display Housing Model 9462. The Model 9480 Display Module is housed in Distant View Housing 9463. Two sizes of nixie display tubes are used in the Display Modules. The Model 9470 Display Module uses display tubes with a 1/2-inch character height, and the Model 9480 Display Module uses display tubes with an 8/10-inch character height.

2.08 FUNCTIONAL BLOCK DIAGRAM

Figure 2-7 following is a functional block diagram for the Level/Noise measurement function.

2.09 SIGNAL FLOW CHART

The Signal Flow Chart, Figure 2-8, can be used for troubleshooting the Level/Noise measurement function, and may also be used when checking the cabling connections between the Control Panel, Equipment Shelf, and Display Housing.

LEVEL/NOISE PERFORMANCE VERIFICATION/CALIBRATION

STEP	PROCEDURE
1	Connect the audio oscillator output to the INPUT jack on the Level/Noise Control Panel. Connect the Fluke 931B rms voltmeter to measure the audio oscillator output.
2	Switch the power off at the Power Supply in the Equipment Shelf. Remove PC Board 9200-2 from the Equipment Shelf. Mount the PC Board on the extender board (stored behind the Timer) then install the extender board in the slot.
3	Switch the power on. Set the audio oscillator controls for a 1 kHz, 0 dBm output at 600 ohms. Press the 600 Ω , TERM, and LEVEL pushbuttons on the Level/Noise Control Panel.
4	Slowly decrease the audio oscillator output level until the Level/Noise Display readout is approximately -11.0 dBm.
5	Set the NORM/TEST slide switch to TEST.
6	Check that the Level/Noise Display readout is approximately -1.0 dBm. Adjust the audio oscillator output to obtain a -1.0 dBm readout and simultaneously light the XX.00 CALIBRATION INDICATOR.
7	Set the NORM/TEST slide switch to NORM. Check that the Level/Noise Display readout is -11.0 dBm and that the XX.00 CALIBRATION INDICATOR on the PC Board front panel remains lit continuously or flickers on and off. If necessary, adjust LINEARITY control R9 for the correct display.
8	Switch the system power off. Remove the PC Board from the extender board. Install the PC Board in its slot. Switch the system power on.
9	Set the rms voltmeter digits to .77460V (equal to 0 dBm at 600 ohms) and to read a null within 1%.
10	Carefully adjust the audio oscillator output level for a null on the rms voltmeter. Check that the Level/Noise Display readout is 00.0 dBm.

LEVEL/NOISE PERFORMANCE VERIFICATION/CALIBRATION (CONT.)

STEP	PROCEDURE
11	If necessary, adjust the RCV CAL. control on the front panel of PC Board 9200-3 for a 00.0 dBm readout on the Level/Noise Display.* Fine adjust the RCV CAL. control until the XX.00 CALIBRATION INDICATOR lamp on PC Board 9200-2 either remains lit continuously or flickers on and off. <u>NOTE</u> Complete steps 12 through 14 only when PC Board 9200-2 has been replaced or the proper results cannot be obtained for step 11.
12	Patch from the +5V test point on the Power Supply front panel to the DET. OUTPUT test point on Level/Noise Receiver PC Board 9200-3.
13	Check that the Level/Noise Display readout is +10.0 dBm and the XX.00 CALIBRATION INDICATOR on PC Board 9200-3 is lit. If necessary, adjust the A to D CAL. control on PC Board 9200-3 for the correct results. Remove the patch.
14	Repeat steps 1 through 11. *This control is used for calibration offset of the Level measurement function. See paragraph 1.06 in Section I.

Table 2-4. Level Function Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	a. Apply a 0 dBm, 1 kHz test signal at a 600 ohm impedance at the INPUT jack of the Level/Noise Control Panel.	Proceed with step 2.	Level/Noise Control Panel is faulty.
	b. Select the TERM and LEVEL pushbuttons on the Level/Noise Control Panel.		
	c. Check that approx. 0.75V rms is present at terminals R and S (common) on the connector at the rear of the Level/Noise Control Panel.		
2.	a. Switch the system power off. Unplug PC Board 9200-1 from the Equipment Shelf and mount it on the extender board (stored behind the Timer Module).	Proceed with step 3.	Level/Noise Control Panel is faulty.
	b. Plug the extender board into the slot for PC Board 9200-1. Switch the system power on.		
	c. Check that the dc voltage between pins J and B (common) on the extender board is approximately 2.2 V.		

Table 2-4. Level Function Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
3.	Check that 1.75V rms approx. is present at terminals T and B (common) on the extender board.	a. Switch the system power off. Remove the extender board from the Equipment Shelf.	PC Board 9200-1 is faulty.
		b. Unplug the PC Board from the extender board.	
		c. Plug the PC Board into the proper slot in the Equipment Shelf.	
		d. Switch the system power on. Proceed with step 4.	
4.	a. Switch the system power off. Unplug PC Board 9200-3 from the Equipment Shelf and mount it on the extender board.	a. Switch the system power off. Remove the extender board from the Equipment Shelf.	PC Board 9200-3 is faulty.
	b. Plug the extender board into the slot for PC Board 9200-3. Switch the system power on.	b. Unplug the PC Board from the extender board. Plug the PC Board into the proper slot on the Equipment Shelf.	
	c. Temporarily increase the input signal level to +1 dBm or higher, then return it to 0 dBm.	c. Proceed with step 5.	

Table 2-4. Level Function Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
	d. Check that the dc voltage between terminals 20 and B (common) is approximately 1.5V.		
5.	a. Switch the system power off. Unplug PC Board 9200-2 from the Equipment Shelf and mount it on the extender board.	Proceed with step 6.	PC Board 9200-2 is faulty.
	b. Plug the extender board into the slot for PC Board 9200-2.		
	c. Switch the system power on. Check that the BCD lines at the terminals of PC Board 9200-2 are at the proper logic levels for the 0.0 dBm input level. See the example (step ⑥) in the introduction to the Signal Flow Chart following.		
6.	Check that the dc voltage between terminals S and R (ground) on the Level/Noise Display connector (at the rear of the Display Housing) is approximately +170V.	Level/Noise Display Module in Display Housing is faulty.	DC Inverter PC Board (Model 9460) in Display Housing is faulty.

Table 2-5. Noise Function Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	a. Apply a 0 dBm, 1 kHz test signal at a 600 ohm impedance to the input jacks on the decade attenuator. Connect the output jacks on the decade attenuator to the INPUT jack of the Level/Noise Control Panel. Set the decade attenuator for 38 dB attenuation.	Proceed with step 2.	Level/ Noise Control Panel is faulty.
	b. Select the TERM and NOISE pushbuttons on the Level/Noise Control Panel.		
	c. Check that 9mV rms approx. is present at terminals R and S (common) on the connector at the rear of the Level/ Noise Control Panel.		
2.	a. Switch the system power off. Unplug PC Board 9200-1 from the Equipment Shelf and mount it on the extender board (stored behind the Timer Module).	Proceed with step 3.	Level/Noise Control Panel is faulty.
	b. Plug the extender board into the slot for PC Board 9200-1. Switch the system power on.		

Table 2-5. Noise Function Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
	c. Check that the dc voltage between pins J and B (common) on the extender board is approx. 0V.		
3.	Check that a 1 kHz tone of approximately 22mV rms is present at terminals T and B (common) on the extender board.	a. Switch the system power off. Remove the extender board from the Equipment Shelf. b. Unplug the PC Board from the extender board. c. Plug the PC Board into the proper slot on the Equipment Shelf. d. Switch the system power on. Proceed with step 4.	PC Board 9200-1 is faulty.
4.	a. Switch the system power off. Unplug PC Board 9200-3 from the Equipment Shelf and mount it on the extender board. b. Plug the extender board into the slot for PC Board 9200-3. Switch the system power on.	a. Switch the system power off. Remove the extender board from the Equipment Shelf. b. Unplug the PC Board from the extender board. Plug the PC Board into the proper slot on the Equipment Shelf.	PC Board 9200-3 is faulty.

Table 2-5. Noise Function Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
	c. Temporarily set the decade attenuator for 35 dB, then return it to 38 dB.	c. Proceed with step 5.	
	d. Check that the dc voltage between terminals 20 and B (common) is between 80 and 90mV.		
5.	a. Unplug PC Board 9200-2 from the Equipment Shelf and mount it on the extender board.	Level/Noise Display Module in the Display Housing is faulty.	PC Board 9200-2 is faulty.
	b. Plug the extender board into the slot for PC Board 9200-2.		
	c. Switch the system power on. Check that the BCD lines at the terminals of PC Board 9200-2 are at the proper logic levels for the +52 dBrn Noise level (see step ⑥ in the introduction to the Signal Flow Chart.		

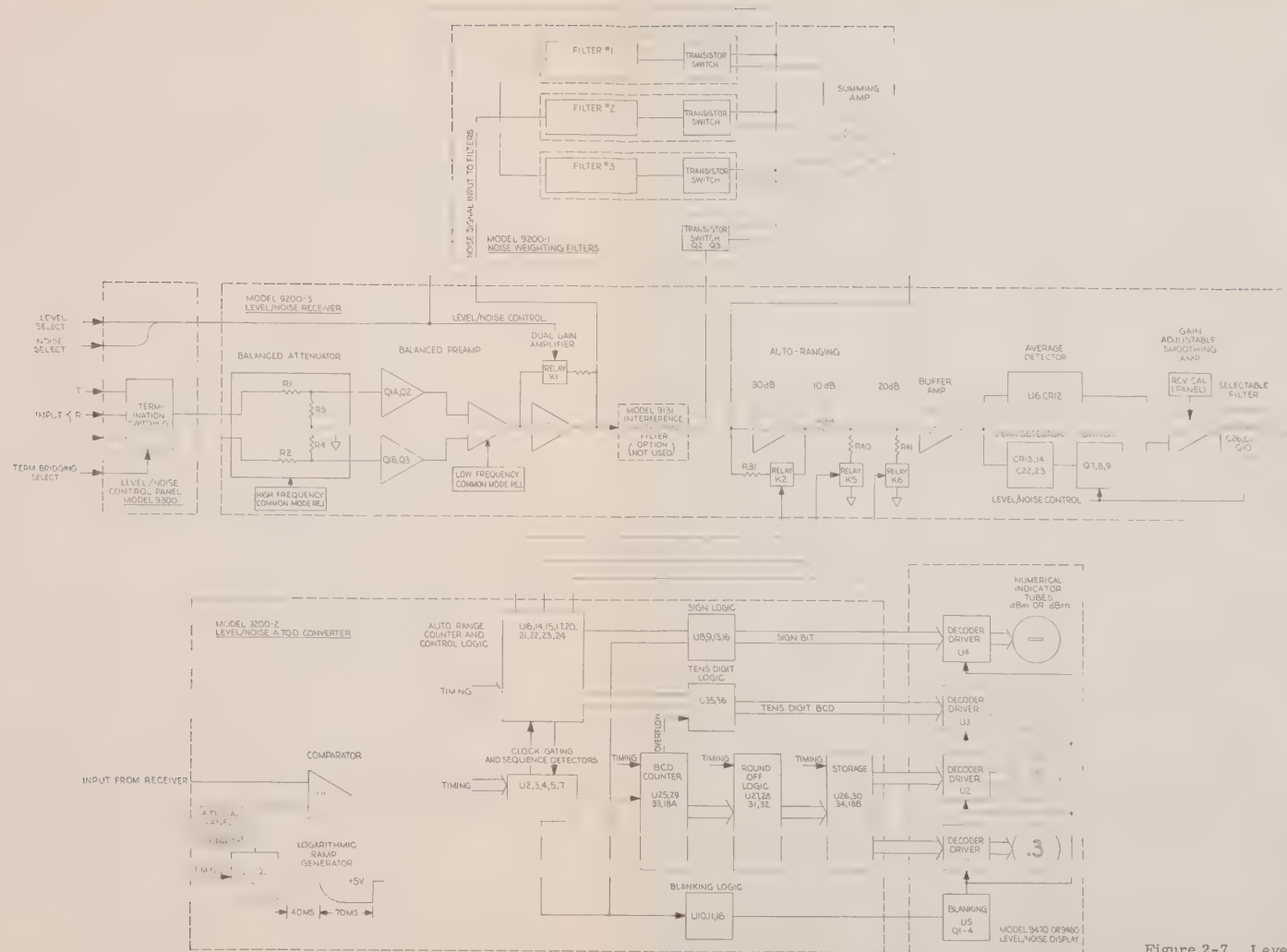


Figure 2-7. Level/Noise Functional Block Diagram

DEDICATED TRANSMISSION MEASURING SYSTEM

SIGNAL FLOW CHARTS

The following signal flow charts for each measurement function are useful when checking cabling connections or tracing signal paths during troubleshooting. A volt-ohm milliammeter (VOM) or digital voltmeter is required for the checks. The example below shows how the charts may be used for quickly checking the various signal paths of a measurement function.

EXAMPLE FOR USING SIGNAL FLOW CHARTS

NOTE

Check the Power Supply and Timer
(in the Equipment Shelf) before
checking any of the measuring
functions (see Flow Charts following).

Level Check (See Level/Noise Signal Flow Chart)

To check the Level/Noise measurement function, the tests are made at particular points in order of the numbered circles.

- ① A test signal of 0.0 dBm (approx. 1.5V rms for an unterminated connection) at approx. 1 kHz is applied to the INPUT jack on the Level/Noise Control Panel. The test signal can be obtained from the WILTRON Oscillator Control Panel or the office milliwatt supply. The front panel controls selected are 600 Ω , TERM, and LEVEL.
- ② The test signal at the output of the Control Panel, terminals R and S, should measure approx. 0.75V rms because of the termination at the input of PC Board 9200-3. If not, the Control Panel is faulty. To check the cable between the Control Panel and the Equipment Shelf, the 0.75V rms can also be measured at terminals 7 and 6 on terminal strip TS8A (if the Level/Noise module is loaded in Side A of the Equipment Shelf) or TS8B (if loaded in Side B).

- ③ The voltage between terminal J and ground (terminal H) on the rear of the Control Panel should be approx. 2.2V dc for Level measurements. If not, the Control Panel is faulty. To check the cable between the Control Panel and the Equipment Shelf, the 2.2V dc can also be measured between terminals 5 and 18 (ground) on terminal strip TS8A (if Side A), or TS8B (Side B).
- ③A This measurement checks if PC Board 9200-3 in the Equipment Shelf is functioning normally. The voltage measured between the PREAMP OUTPUT and GND test points on the front panel of the PC Board should be approx. 1.75V rms.
- ④ The output of PC Board 9200-1 is checked at the OUTPUT and GND test points on the front panel of the board. The voltage measured should be approx. 1.75V rms.
- ⑤ The output of PC Board 9200-3 is checked at the DET OUTPUT and GND test points on the front panel. This voltage should be approx. 1.5V dc.
- ⑥ PC Board 9200-2 is checked for the proper binary coded decimal (BCD) outputs. There are 3 sets of binary lines, with each set numbered 8-4-2-1. As shown in Table 2-7, each line is checked for the correct voltage for the test signal value. For example, if the test signal is exactly 0.0 dBm, all BCD lines for the most significant digit, middle digit, and least significant digit will be a binary 0, or approx. 0V dc to ground. However, if the test signal is say, +1.2 dBm, the approx. BCD line voltages will be as follows:

	M. S. D.				M. D.				L. S. D.				Polarity
BCD Line	8	4	2	1	8	4	2	1	8	4	2	1	-
Terminal	S	T	U	V	W	X	Y	Z	15	16	17	18	R
DC Voltage Measured	0	0	0	0	0	0	0	3.5V	0	0	3.5V	0	0
Decimal Value	0				1				2				+

The corresponding BCD voltages at the Display Housing can be checked to determine if the cabling between the Equipment Shelf and the Display Housing is faulty. Refer to bottom right corner on the Level/Noise Chart.

- ⑦ The impedance select lines are checked with the 135, 600, and 900 ohm pushbuttons selected in turn. See Table 2-8. For example, with the 600 Ω pushbutton pressed, the voltages are as follows:

<u>Control Panel Terminals</u>	<u>Equip. Shelf Terminals TS8A (Side A) or TS8B (Side B)</u>	<u>Voltage Measured</u>
K to H (ground)	14 to 18 (ground)	4.8V dc approx.
P to H (ground)	15 to 18 (ground)	0V dc approx.

Autorangeing

If the display readout does not operate properly throughout the measurement range, the autorangeing control lines should be checked for the proper voltages (see Table 2-10 on the Level/Noise chart). For example, for a Level input of -16 dBm, the autorangeing control line voltages should be as follows:

<u>PC Board 9200-2 Terminals</u>	<u>PC Board 9200-3 Terminals</u>	<u>Approx. Voltage Measured</u>
F	T	+3.5V to +5.0V dc
6	U	0V dc
7	S	0V dc

If the autorangeing control voltages are abnormal, PC Board 9200-2 is faulty.

TROUBLESHOOTING

The other measurement functions can be checked in a similar manner to that described above by using the appropriate signal flow chart.

- NOTES**
- Check that Timer and Power Supply are serviceable before troubleshooting the Level/Noise function. See Sections VIII through X in this manual.
 - Signal measured at PREAMP OUTPUT test point on front panel of PC Board 9200-3.
 - Signal measured at OUTPUT test point on front panel of PC Board 9200-1.
 - Signal measured at DET. OUTPUT test point on front panel of PC Board 9200-3.
 - Signal measured at NOISE INPUT test point on front panel of PC Board 9200-1.
 - Connection between terminals 15 and H is through a trace on the Equipment Shelf motherboard and J3A, terminal 14 (Side A) or J3B, terminal 15 (Side B).
 - Audio monitor output of approximately 1V rms (900 ohms impedance) for both Level and Noise is available at TS12, terminals 13 and 12 (common) for Side A, or terminals 1 and 2 (common) for Side B.
 - Use a step attenuator (balanced) to reduce the 0 dBm test signal to -38 dBm at the INPUT jack to make a Noise reading (nominal value 52 dBm).
 - The interface connections for the Model 9303 and 9306 Level/Noise Control Panels are the same as for the Model 9301 or 9304 panels, except that they require terminal N connected to the bay or rack ground.
 - Cabling between Control Panel and Equipment Shelf may be up to 250 ft. long. Cabling between Display Housing and Equipment Shelf may be up to 1000 ft. long.
 - Display Housing Model 9461 may house up to 2 Display Modules. Display Housing Models 9462 and 9463 may house up to 3 Display Modules.
 - Only one DC Inverter required for up to 3 Display Modules.
 - Three control lines for autoranging. See Table 2-10.
 - All integrated circuits on the Display Module PC Board are mounted in sockets to enable easy replacement.

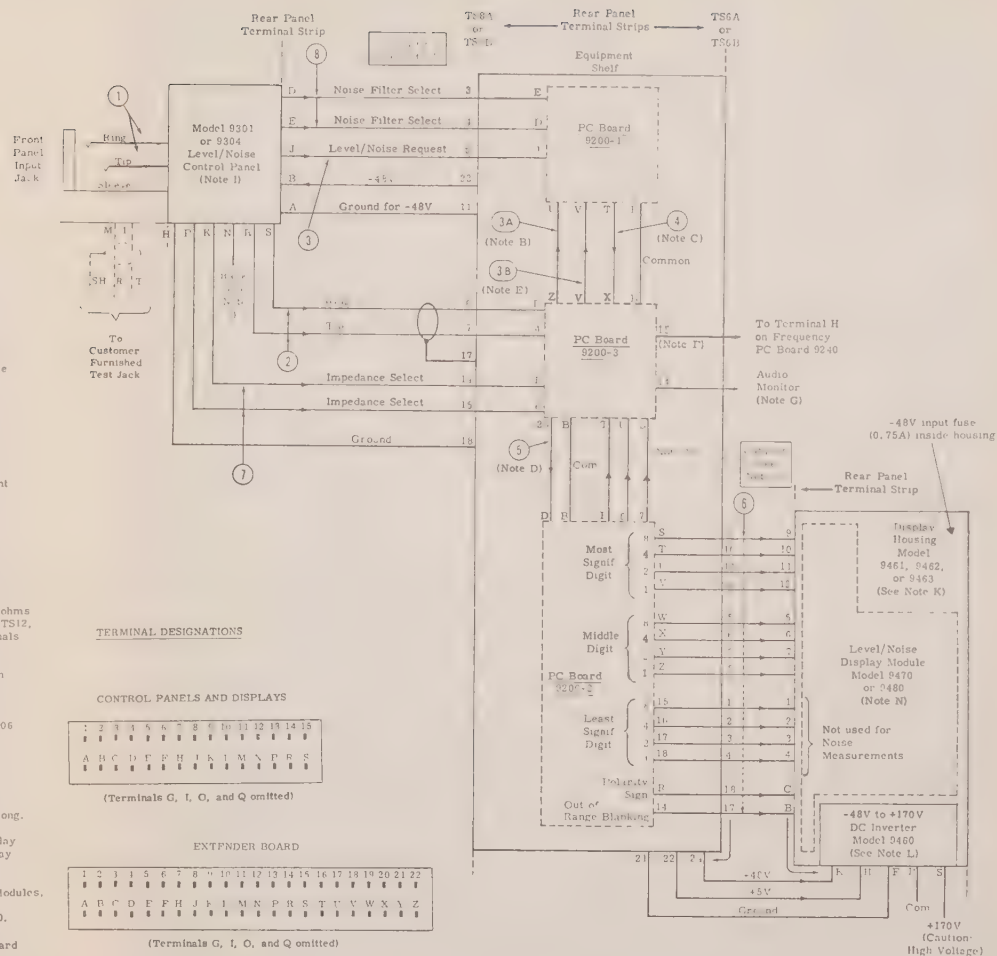


Figure 2-8. Level/Noise Signal Flow Chart, Sheet 1 of 2

HOW TO USE THE CHART

1. Use a VOM or digital voltmeter for the measurements.
 2. Make the checks in the order shown below. If a particular voltage is abnormal, but the previous measurements are normal, it is likely that the PC Board between these two points is faulty.
- NOTE:** On new installations, the cabling should be checked first for wiring errors.
3. If a spare PC Board of the same model is available, it can be substituted for the suspect board to see if the fault is cleared.

LEVEL CHECKS		
TEST POINT	READING	REMARKS
① (Note A)	1.5V rms (0.0 dBm) approx., tip to ring.	Test signal: 0.0 dBm, approx. 1 kHz. Level/Noise controls set to 600 ohms, TERM, and LEVEL.
②	0.75V rms approx. tip to ring	Same as above.
③	2.2V dc approx. to ground	Same as above.
④A	1.75V rms approx. to common	Same as above.
④	Same as above.	Same as above.
⑤	1.5V dc approx. to common	Same as above.
⑥	See Table 2-7.	Same as above.
⑦	See Table 2-8.	Check with 135, 600 and 900 ohms selected in turn.

Table 2-8. Impedance Selection Logic States

TS8A or TS8B		
Desired Impedance	Term. 14	Term. 15
135 Ω	L	H
600 Ω	H	L
900 Ω	L	L

H = approx. 4.8V dc
L = approx. 0V dc

Table 2-9. Noise Filter Selection Logic States

TS8A or TS8B		
Desired Noise Filter*	Term. 3	Term. 4
Position 1	L	H
Position 2	L	L
Position 3	H	L

H = approx. 4.8V dc
L = approx. 0V dc

*Positions 1, 2, and 3 can be equipped with any 3 of the following noise weighting filters: C Message, 3 kHz Flat, 15 kHz Flat, Program, or the 1010 Hz notch filter. For CCITT standards, the Psophometric and Programme filters are available.

NOISE CHECKS		
TEST POINT	READING	REMARKS
① (Note A)	-38 dBm See Note H.	Test signal: -38 dBm, approx. 1 kHz. Level/Noise controls set to 600 ohms, TERM, and NOISE C MSG.
②	8mV rms approx. tip to ring	Same as above.
③	0V dc approx. to common	Same as above.
④	22mV rms approx. to common	Same as above.
⑤	Same as above.	Same as above.
⑥	80 to 90mV dc to common	Same as above.
⑦	See Table 2-7.	Same as above.
⑧	See Table 2-8.	Check with each noise filter selected in turn.

Table 2-10. Level/Noise Autoranging Control

	AUTO RANGE (dB)	TERMINALS ON PC BOARD (AK1) 9200-2			TERMINALS ON PC BOARD 9200-1		
		1	2	3	1	2	3
LEVEL (dBm)	+10 to +2	0	1	0	1	1	0
	0 to -12	1	0	1	1	0	0
	-10 to -22	1	0	0	1	0	0
	-20 to -32	0	1	0	0	1	0
	-30 to -42	0	0	1	0	0	1
	-40 to -52	0	0	0	0	0	0
NOISE (dBm)	+50 to +12	1	1	0	1	0	0
	+40 to +52	1	0	1	0	0	1
	+30 to +42	1	0	0	1	0	0
	+20 to +32	0	1	0	0	1	0
	+10 to +22	0	0	1	0	0	1
	0 to +12	0	0	0	0	0	0

Table 2-7. BCD Logic Levels for Decimal Digits at Terminals on PC Board 9200-2 and Display Module.

ASSEMBLY TERMINAL STRIP	TERMINAL DESIGNATION OF BCD LINES		IDENTIFICATION
	1	2	
PC Board 9200-2	8	1	Most Significant Digit
	W	N	Middle Digit
	10	16	Least Significant Digit
		8	Polarity Sign
		17	Out of Range Blanking
Display Module	8	10	Most Significant Digit
	8	6	Middle Digit
	1	2	Least Significant Digit
		0	Polarity Sign
		6	Out of Range Blanking

PC Board 9200-2	TERMINAL DESIGNATION OF BCD LINES		IDENTIFICATION
	1	2	
PC Board 9200-2	8	1	Decimal 0
	0	0	Decimal 1
	8	0	Decimal 2
	0	1	Decimal 3
	0	1	Decimal 4
	0	1	Decimal 5
	0	1	Decimal 6
	0	1	Decimal 7
	0	1	Decimal 8
	0	1	Decimal 9
Display Module	8	1	Decimal 0
	0	0	Decimal 1
	8	0	Decimal 2
	0	1	Decimal 3
	0	1	Decimal 4
	0	1	Decimal 5
	0	1	Decimal 6
	0	1	Decimal 7
	0	1	Decimal 8
	0	1	Decimal 9

Figure 2-8. Level/Noise Signal Flow Chart, Sheet 2 of 2

SECTION III

FREQUENCY MEASUREMENT FUNCTION

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Table 3-1. Specifications for Frequency Measurement Function

Operates from an output of the 9200 Level/Noise measurement module which provides the automatic level ranging.

FREQUENCY RANGE: Below 100 Hz to above 20 kHz with a four digit display.

RESOLUTION: 1 Hz or 10 Hz, strap selectable.

ACCURACY: 1 Hz plus one part in 10^5 .

DISPLAY DIGITS AUTOMATICALLY BLANK whenever the level readout blanks.

READING UPDATE RATE: 9 times per second.

FREQUENCY RANGE of 100 Hz to 60 kHz is available on special order.

3.01 DESCRIPTION OF FUNCTION

A digital readout for Frequency measurements can be added to the Display Housing for the Level/Noise readout as shown in Figure 1-1 of Section I. The Frequency Display is used in conjunction with the Level measurement function only to provide a simultaneous readout of the level and frequency of a test signal. The Frequency measurement module consists of one PC Board (Model 9240) installed in the Equipment Shelf in addition to the Level/Noise measuring modules and the timer module. Specifications for the Frequency measurement function are provided in Table 3-1 following.

3.02 OPERATING PROCEDURES

(A) Operation of Frequency Display

The Frequency Display provides a digital readout of the frequency of a signal from 100 Hz to 20 kHz with a level between -52 and +10 dBm. The display is blanked for signal levels outside of this range. The resolution of the Frequency Display readout is either 1 Hz or 10 Hz depending on the strapping connections on the mother board in the Equipment Shelf. Refer to paragraph 3.05(B) for instructions for changing the Frequency Display resolution.

FREQUENCY DISPLAY OPERATIONAL CHECK

STEP	PROCEDURE
1	Perform steps 1 through 4 of the Level/Noise operational check in Section II.
2	Check that the Frequency Display readout is 1.000 kHz ± 1 Hz or ± 10 Hz depending on the frequency resolution strapped in. (See paragraph 3.05(B)).

(B) Frequency Display Operational Check

The above procedure should be performed periodically to check the Frequency Display for proper operation.

(C) Frequency Measurements

Frequency measurements are made by patching the test signal to the INPUT jack on the Level/Noise Control Panel and noting the readout in kHz on the Frequency Display. The display is blanked if the test signal is outside the Level range of -52 to +10 dBm. The Frequency Display is also blanked when Noise measurements are being made.

3.03 PERFORMANCE VERIFICATION/ CALIBRATION

The procedure for verifying the performance of the Frequency measurement function is identical to that for the Level measurement function. Refer to Section II for additional information.

3.04 THEORY OF OPERATION

Refer to Figure 3-1. The Frequency function makes use of the Level/Noise input and autoranging circuits. The ac test signal from the Level/Noise Measuring Module is squared by a Schmitt trigger and applied to one input of a frequency comparator. A second input to the frequency comparator is obtained from a decade divider. If the frequency of the test signal from the Level/Noise module is either higher or lower than the output from the decade divider, the frequency comparator applies a correction signal to

the frequency control circuit. The output of the frequency control circuit is a negative dc voltage that controls the frequency of a voltage controlled oscillator (VCO). The VCO oscillates at 20 times the frequency of the input test signal. The VCO output frequency is divided by 2 by a binary divider and then applied through the counter gating circuits to the counters. The BCD outputs from the counters are applied to the counter storage circuits, which drive the display tube decoder/drivers in the Display Housing. The X10 frequency output of the VCO is also fed to the decade divider to obtain a reference frequency for the frequency comparator circuits.

3.05 STRAPPING OPTIONS

(A) General

The strapping options that can be made by the operator (craftsman) for the Frequency measurement function are described below. The initial strapping selection is normally made upon installation of the equipment.

CAUTION

ENSURE POWER IS OFF
WHEN MAKING STRAPPING
CONNECTIONS.

(B) Frequency Resolution

The Frequency Display provides a digital readout of the test signal frequency with a resolution of either 10 Hz or 1 Hz. The 1 Hz resolution strapping provides

frequency readings from 0.100 kHz to 9.999 kHz, while the 10 Hz resolution provides readings from 0.10 kHz to 20.00 kHz. The desired resolution is selected by appropriate strapping on the mother board at the rear of the Equipment Shelf. Arrange the strapping as follows:

1 Hz Resolution: Ensure strap is removed between terminals 17 and 18 on terminal strip TS9A (for Side A) or TS9B (for Side B).

10 Hz Resolution: Strap between terminals 17 and 18 on terminal strip TS9A (Side A) or TS9B (Side B).

The Frequency Display resolution can also be controlled by the FREQ range switch on the Oscillator Control Panel. This strapping option is useful when the Frequency Display is being used to monitor the Oscillator output frequency and it is desired that the most significant digit is displayed for both the low and high frequency ranges. To incorporate this option, strap between terminals 9 and 17 on terminal strip TS9A(SideA) or TS9B (Side B).

3.06 TROUBLESHOOTING

Table 3-2 is a troubleshooting chart for the Frequency measurement function. Refer also to the Signal Flow Chart, Figure 3-2, for troubleshooting assistance. The test equipment required is a Digital Multimeter (WILTRON Model 9270 or equivalent) and a 0 dBm, 1 kHz test signal source (WILTRON Model 9320 Oscillator or equivalent).

3.07 PARTS LIST

Table 3-3 lists the WILTRON

part numbers for the replaceable assemblies used with the Frequency measurement function.

Table 3-3. Parts List for Frequency Measurement Function

<u>DESCRIPTION</u>	<u>WILTRON PART NO.</u>
Frequency Measuring Module (Note 1)	9240
Frequency Display Module, Close View or Distant View (Note 2)	9474, 9484

NOTES:

1. Frequency Measuring Module operates from the Level/Noise measurement function.
2. The Model 9474 Display Module is housed in either the Panel Display Housing (9461) or in the Close View Display Housing (9462). The Model 9484 Display Module is housed in the Distant View Display Housing (9463).

3.08 FUNCTIONAL BLOCK DIAGRAM
Figure 3-1 is a functional block diagram of the Frequency measurement function.

3.09 SIGNAL FLOW CHART

The Signal Flow Chart, Figure 3-2, can be used for troubleshooting the Frequency measurement function, and may also be used when checking the cabling connections between the Level/Noise Control Panel, Equipment Shelf, and Frequency Display Housing.

Table 3-2. Frequency Measurement Function Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	a. Switch the system off. Remove Level/Noise PC Board 9200-3 from the Equipment Shelf and mount it on the extender board (stored behind the Timer Module).	a. Switch the system power off. Unplug the extender board from the Equipment Shelf. Remove PC Board 9200-3 from the extender board.	Level/Noise PC Board 9200-3 is faulty.
	b. Plug the extender board into the slot for PC Board 9200-3. Switch the system power on.	b. Plug PC Board 9200-3 into the proper slot in the Equipment Shelf.	
	c. Apply a 0 dBm, 1 kHz test signal at 600 ohms impedance to the INPUT jack on the Level/Noise Control Panel. Select the TERM and LEVEL push-buttons.	c. Proceed with step 2.	
	d. Check that approx. 0.75V AC is present at terminals 15 and B (common) on the extender board.		
2.	a. Remove Frequency PC Board 9240 from the Equipment Shelf and mount it on the extender board. Plug the extender board into the PC Board slot.	PC Board in Frequency Display Module is faulty.	PC Board 9240 is faulty

Table 3-2. Frequency Measurement Function Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
	b. Adjust the 0 dBm test signal source to obtain a 1.001 kHz output frequency that is as stable as possible (as read on the frequency counter). c. Switch the system power on. Check that the BCD lines at the terminals on PC Board 9240 are at the proper logic levels for the 1.001 kHz frequency. See the example (step ⑥) in the introduction to Figure 2-8 in Section II.		
<u>NOTE</u> If the mother board is strapped for 1 Hz resolution, the dc voltage between terminal 22 and B on the PC Board may randomly switch between 4.4V and 0.4V, indicative of a frequency change of 1 Hz. If the mother board is strapped for 10 Hz resolution, the dc voltage between terminal 18 and B may randomly switch between 0.4V and 4.4V (a 10 Hz change).			

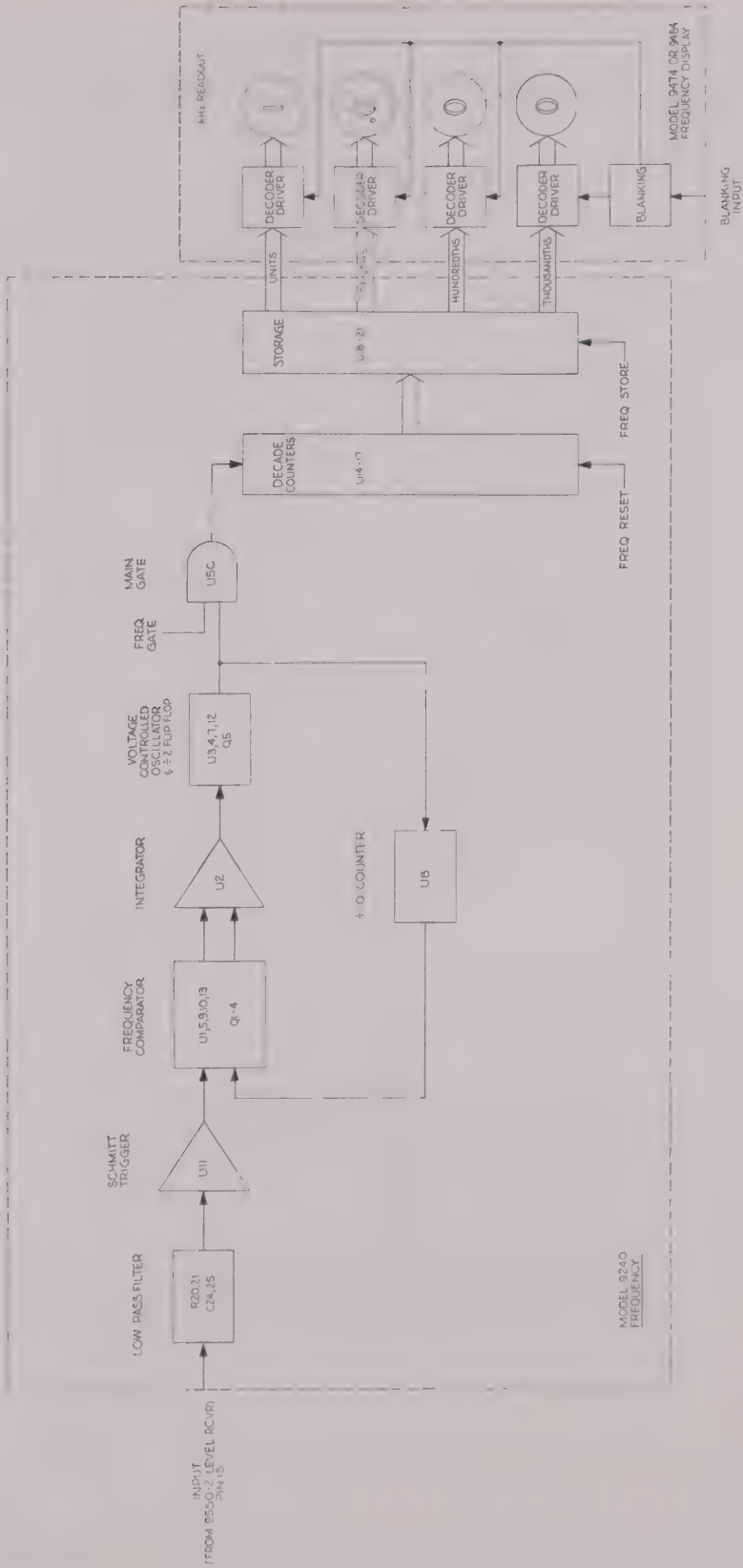
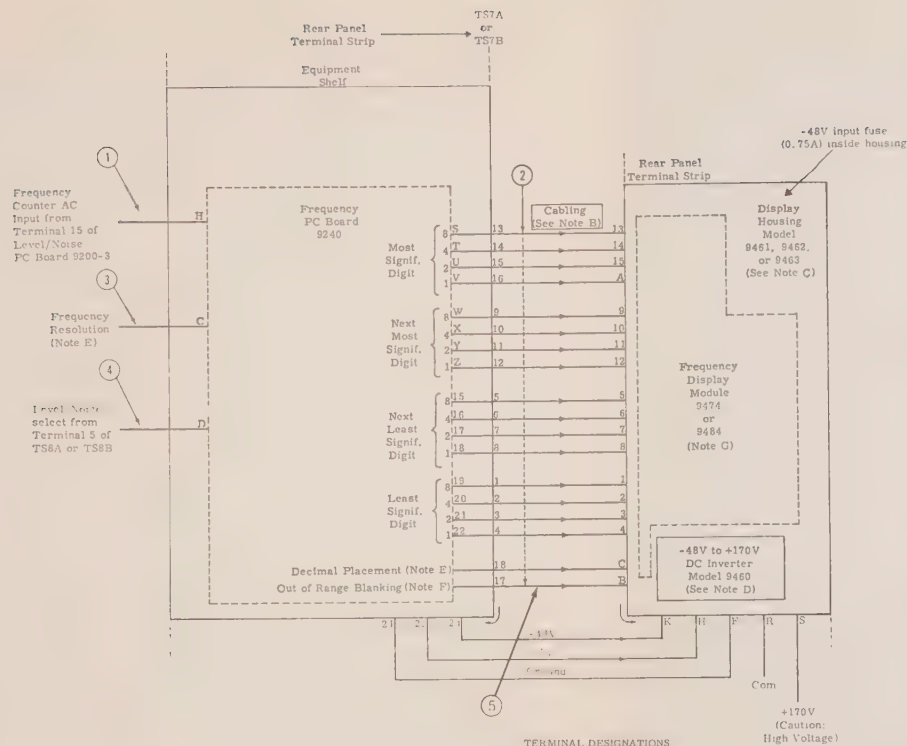


Figure 3-1. Frequency Measurement Function, Functional Diagram



SECTION IV

OSCILLATOR FUNCTION

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4. GENERAL

4.01 DESCRIPTION OF FUNCTION

The Oscillator Control Panel (see Figure 4-1) provides pushbutton selection for frequency, output level, and output impedance. One of eight fixed frequencies (customer-selected) or a variable frequency from 100 Hz to 20 kHz can be selected as a test signal. One of three customer-selected fixed output levels, variable level (+10 to -26 dBm), or an OFF position (with a 600 or 900 ohm termination) can also be selected. Selection of either a 600 ohm or 900 ohm output impedance is provided. Other Oscillator Control Panels are available that provide 12 or 18 push-

button-controlled test frequencies, plus variable, with a level range variable from +10 to -40 dBm. Oscillator Control Panel Model 9321 (shown on page 4-4), with 12 preset frequencies, occupies 1 3/4" of space in a 19" or 23" rack. The Model 9323 (not shown), with 18 preset frequencies, occupies 2" of space in a 23" or 27" rack.

The Oscillator output is provided through the front panel OUTPUT jack or through customer-furnished jack and lamp multiples described in paragraph 4.01(A). The Control Panel has Level and Frequency calibration controls for each preset frequency and level at the rear of the panel. The Oscillator measuring module consists of one PC board (Model 9220). It is installed in the CME Shelf in addition to the timer module. Specifications for the Oscillator measurement function are provided in Table 4-1.

(A) Customer-Furnished Jack and Lamp Multiples

The Oscillator function can also be used through a customer-furnished jack for test signal output and an indicator lamp for BUSY status. The desired number of jacks are connected in parallel with the Oscillator OUTPUT jack through the wire wrap terminals at the rear of the panel. The indicator lamps can be wired to provide a BUSY indication at all test locations except the one in use. Selection of the Oscillator output level, frequency, and impedance must be made at the Control Panel.

(B) Holding Coil Strapping Option

A holding coil can be strapped in (as desired) across the tip and ring contacts of the Oscillator OUTPUT jack. The holding coil provides off-hook supervision on 2-wire Outgoing Trunks by completing the path for the dc loop current. Figure 4-2 shows the holding coil strapping options.

Specifications, Operation

All of the above options are described in the WILTRON DTMS Engineering Information Manual. Refer to the AW drawings.

Table 4-1. Specifications for Oscillator Function

FREQUENCY RANGE: Variable from 100 Hz to 20 kHz continuously in two ranges of 100 to 3980 Hz and 4.02 to 20 kHz.

PROGRAMMED FREQUENCIES: 304, 404, 704, 1004, 2304, 2804, 3004, 3204, and variable.

Note: Frequencies (8) may be specified at time of order.

LEVEL: Adjustable from +10 dBm to -26 dBm.

OSCILLATOR CONTROL PANEL: Has programmed levels of 0, -2, and -16 dBm plus the variable range of +10 to

-26 dBm (down to -40 dBm for the Model 9321).

Note: Pre-set levels (3) may be specified at time of order.

ACCURACY: ± 0.1 dB.

LEVEL VARIATION WITH FREQUENCY: ± 0.1 dB, 100 Hz to 9999 Hz.

TOTAL HARMONIC DISTORTION: >40 dB down from the output Level.

OUTPUT IMPEDANCE: 600 or 900 ohms balanced. Return Loss greater than 30 dB.

PROGRAMMED FREQUENCIES AND LEVELS are selected by illuminated pushbuttons.

LOOP HOLDING: A holding coil is provided which can be strapped in or out of circuit as desired (see paragraph 4.01(B)).

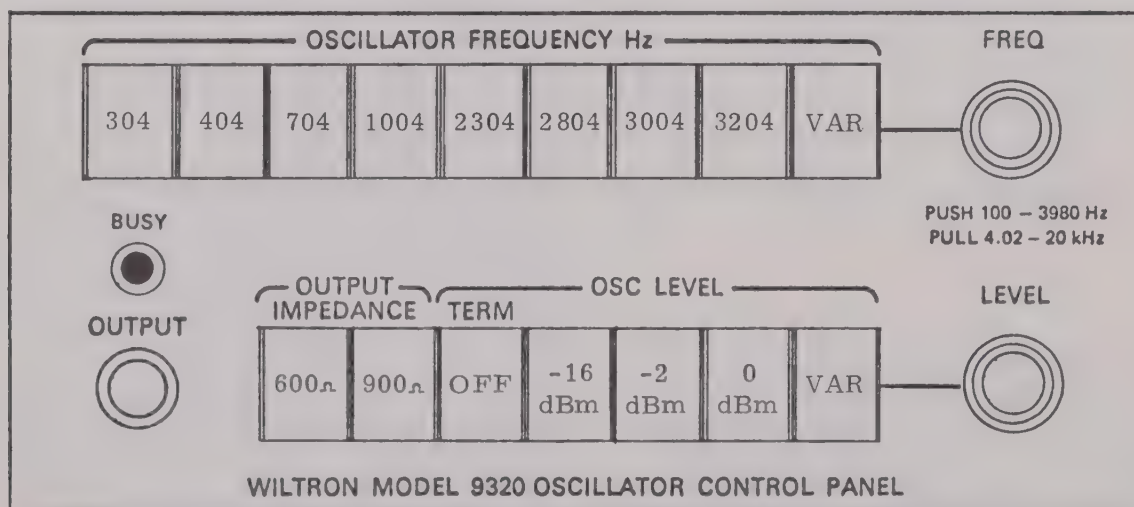


Figure 4-1. Oscillator Control Panel

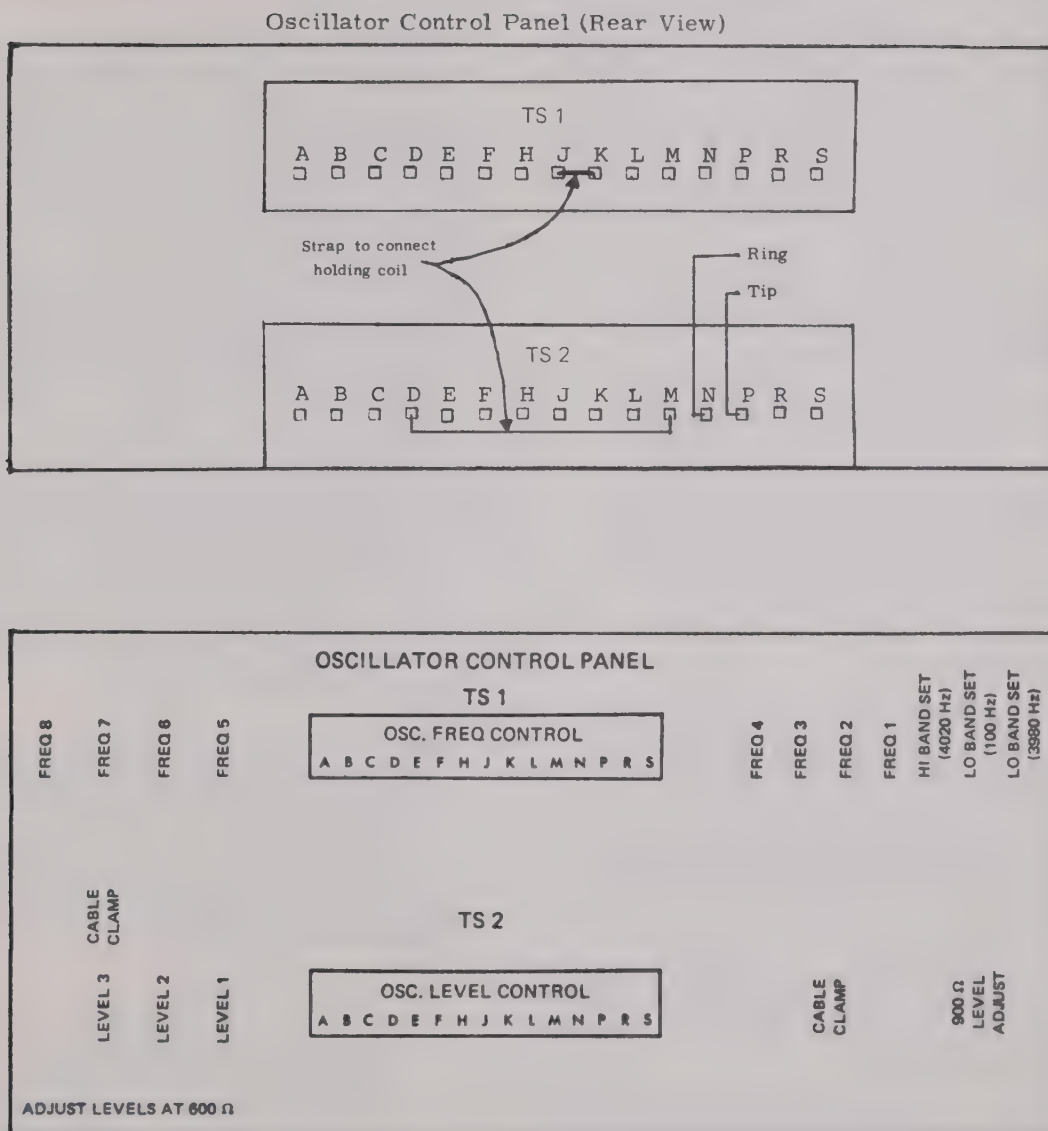


Figure 4-2. Location of Oscillator Connections and Adjustments



Oscillator Control Panel Model 9321

4.02 OPERATING PROCEDURES

(A) Function of Controls, Indicators, and Connectors

Table 4-2 describes the function of the controls, indicators, and connectors on the Oscillator Control Panel.

Table 4-2. Function of Controls, Indicators, and Connectors

BUSY: Light emitting diode indicator lamp. When the indicator is not lit, the Oscillator is available for use. The indicator is lit only when the Oscillator is being used at another test location.

OUTPUT: Western Electric Type 310 jack (Type 309 optional) connected tip and ring. Sleeve is floating to permit customer sleeve conditioning. The Oscillator sending equipment is accessed when a plug is inserted in the jack if the BUSY indicator is not already lit.

OUTPUT IMPEDANCE: Two back-lighted pushbutton switches. Provides selection of either 600 or 900 ohms (balanced) output impedance.

OSC LEVEL: Five back-lighted pushbutton switches. Provides selection of any one of three fixed Oscillator signal levels, a variable level when used in conjunction

with the LEVEL control, or an OFF position that provides a reference termination of 600 Ω or 900 Ω depending on the OUTPUT IMPEDANCE selection.

LEVEL: Variable control used with VAR pushbutton. When VAR pushbutton is pressed, the LEVEL control can be adjusted to obtain an Oscillator output level from -26 dBm up to +10 dBm.

OSCILLATOR FREQUENCY Hz: Bank of nine interlocked back-lighted pushbutton switches used to select Oscillator output frequency. Any one of eight fixed frequencies can be selected, or when VAR pushbutton is pressed any frequency from 100 Hz to 20 kHz can be selected using the FREQ control.

FREQ: Combination push-pull switch and potentiometer used in conjunction with VAR pushbutton. When control is pushed in, a frequency from 100 Hz to 3980 Hz can be selected. When the control is pulled out, a frequency from 4020 Hz to 20 kHz can be selected.

NOTE

Calibration potentiometers (screwdriver adjust) for the frequency, level, and impedance pushbuttons are located on the rear panel of the Oscillator.

(B) Operational Check

The following procedure should be performed periodically to ensure that the Oscillator is operating properly.

(C) Frequency Response (Attenuation Distortion) Measurements

Frequency response or attenuation distortion measurements are made using either the Oscillator or a remote signal source. For local measurements, the Oscillator output is applied to the input of the circuit or device under test, and the output level of the device or circuit measured versus frequency. For remote measurements, a signal is applied at the far end and only the level measurement function is required at the near end to measure the output level versus frequency of the circuit or device.

4.03 PERFORMANCE VERIFICATION/
CALIBRATION

The performance verification/calibration procedure enables the user to verify that

the Oscillator function meets the design specifications. This check may be performed upon installation of the equipment (prior to use), periodically, or when failure of the measurement function is suspected.

The level adjustment on the front panel of the Oscillator Module (in the CME Shelf) must be made before those at the rear of the Oscillator Control Panel. The level calibration has been set at the factory to provide a true level in dBm (see paragraphs 1.06(A) and 1.06(B)). The following test equipment (or equivalent) is required for the procedure:

- a. Fluke 931B RMS Voltmeter
- b. Pomona Electronics Model 1296 Adapter, double banana jacks to BNC plug.
- c. Test cable, Type 310 plug to double banana plug.
- d. Resistor, 600 ohms, 0.1% tolerance
- e. Resistor, 900 ohms, 0.1% tolerance
- f. HP5246L Frequency Counter

OPERATIONAL CHECK

STEP	PROCEDURE
1	Check the Oscillator output level and frequency using steps 2 through 5. If the system does not include the Level/Noise and Frequency measurement functions proceed with steps 6 through 9.
2	Patch from the OUTPUT jack on the Oscillator Control Panel to the INPUT jack on the Level/Noise Control Panel. *
3	Select an Oscillator output of 1000 Hz, 0 dBm at 600 ohms.
4	Check that the BUSY indicator is not lit at the Level/Noise and the Oscillator test locations. * Press the 600 Ω , TERM, and LEVEL pushbuttons on the Level/Noise Control Panel.
5	Check that the Level/Noise Display readout is approximately 0 dBm.
6	Patch from the OUTPUT jack on the Oscillator Control Panel to a 600 ohm level meter, such as the Western Electric 21A TMS or equivalent.
7	Set the Oscillator output for 0 dBm at 600 ohms.
8	Check that the BUSY indicator is not lit at the Oscillator test location, then check that the reading on the level meter is approximately 0 dBm.
9	Transfer the patch cord from the level meter to a frequency counter. Set the Oscillator for an output frequency of 1000 Hz. Check that the frequency counter readout is approximately 1000 Hz. Remove the patch cord.
	*Measurements may also be made through customer-supplied jack multiples. Refer to paragraph 4.01(A) for details regarding this option.

FREQUENCY RESPONSE (ATTENUATION DISTORTION) MEASUREMENTS
USING REMOTE OSCILLATOR

STEP	PROCEDURE
1	Connect the output of the circuit or device under test to measure the test signal level as described in Section II.
2	If the BUSY light is lit at the Level/Noise test location, wait until the light goes out before making measurements.
	<u>NOTE</u> When the BUSY indicator is lit, the Level/Noise measurement function is being used at another test location.
3	Press the LEVEL pushbutton and the appropriate IMPEDANCE and INPUT pushbuttons.
4	Note the level in dBm on the Level/Noise Display at each frequency (or frequency range) of interest.

(B) Operational Check

The following procedure should be performed periodically to ensure that the Oscillator is operating properly.

(C) Frequency Response (Attenuation Distortion) Measurements

Frequency response or attenuation distortion measurements are made using either the Oscillator or a remote signal source. For local measurements, the Oscillator output is applied to the input of the circuit or device under test, and the output level of the device or circuit measured versus frequency. For remote measurements, a signal is applied at the far end and only the level measurement function is required at the near end to measure the output level versus frequency of the circuit or device.

4.03 PERFORMANCE VERIFICATION/
CALIBRATION

The performance verification/calibration procedure enables the user to verify that

the Oscillator function meets the design specifications. This check may be performed upon installation of the equipment (prior to use), periodically, or when failure of the measurement function is suspected.

The level adjustment on the front panel of the Oscillator Module (in the CME Shelf) must be made before those at the rear of the Oscillator Control Panel. The level calibration has been set at the factory to provide a true level in dBm (see paragraphs 1.06(A) and 1.06(B)). The following test equipment (or equivalent) is required for the procedure:

- a. Fluke 931B RMS Voltmeter
- b. Pomona Electronics Model 1296 Adapter, double banana jacks to BNC plug.
- c. Test cable, Type 310 plug to double banana plug.
- d. Resistor, 600 ohms, 0.1% tolerance
- e. Resistor, 900 ohms, 0.1% tolerance
- f. HP5246L Frequency Counter

OPERATIONAL CHECK

STEP	PROCEDURE
1	Check the Oscillator output level and frequency using steps 2 through 5. If the system does not include the Level/Noise and Frequency measurement functions proceed with steps 6 through 9.
2	Patch from the OUTPUT jack on the Oscillator Control Panel to the INPUT jack on the Level/Noise Control Panel. *
3	Select an Oscillator output of 1000 Hz, 0 dBm at 600 ohms.
4	Check that the BUSY indicator is not lit at the Level/Noise and the Oscillator test locations. * Press the 600 Ω , TERM, and LEVEL pushbuttons on the Level/Noise Control Panel.
5	Check that the Level/Noise Display readout is approximately 0 dBm.
6	Patch from the OUTPUT jack on the Oscillator Control Panel to a 600 ohm level meter, such as the Western Electric 21A TMS or equivalent.
7	Set the Oscillator output for 0 dBm at 600 ohms.
8	Check that the BUSY indicator is not lit at the Oscillator test location, then check that the reading on the level meter is approximately 0 dBm.
9	Transfer the patch cord from the level meter to a frequency counter. Set the Oscillator for an output frequency of 1000 Hz. Check that the frequency counter readout is approximately 1000 Hz. Remove the patch cord.
	*Measurements may also be made through customer-supplied jack multi- ples. Refer to paragraph 4.01(A) for details regarding this option.

FREQUENCY RESPONSE (ATTENUATION DISTORTION) MEASUREMENTS
USING REMOTE OSCILLATOR

STEP	PROCEDURE
1	Connect the output of the circuit or device under test to measure the test signal level as described in Section II.
2	If the BUSY light is lit at the Level/Noise test location, wait until the light goes out before making measurements.
	<u>NOTE</u> When the BUSY indicator is lit, the Level/Noise measurement function is being used at another test location.
3	Press the LEVEL pushbutton and the appropriate IMPEDANCE and INPUT pushbuttons.
4	Note the level in dBm on the Level/Noise Display at each frequency (or frequency range) of interest.

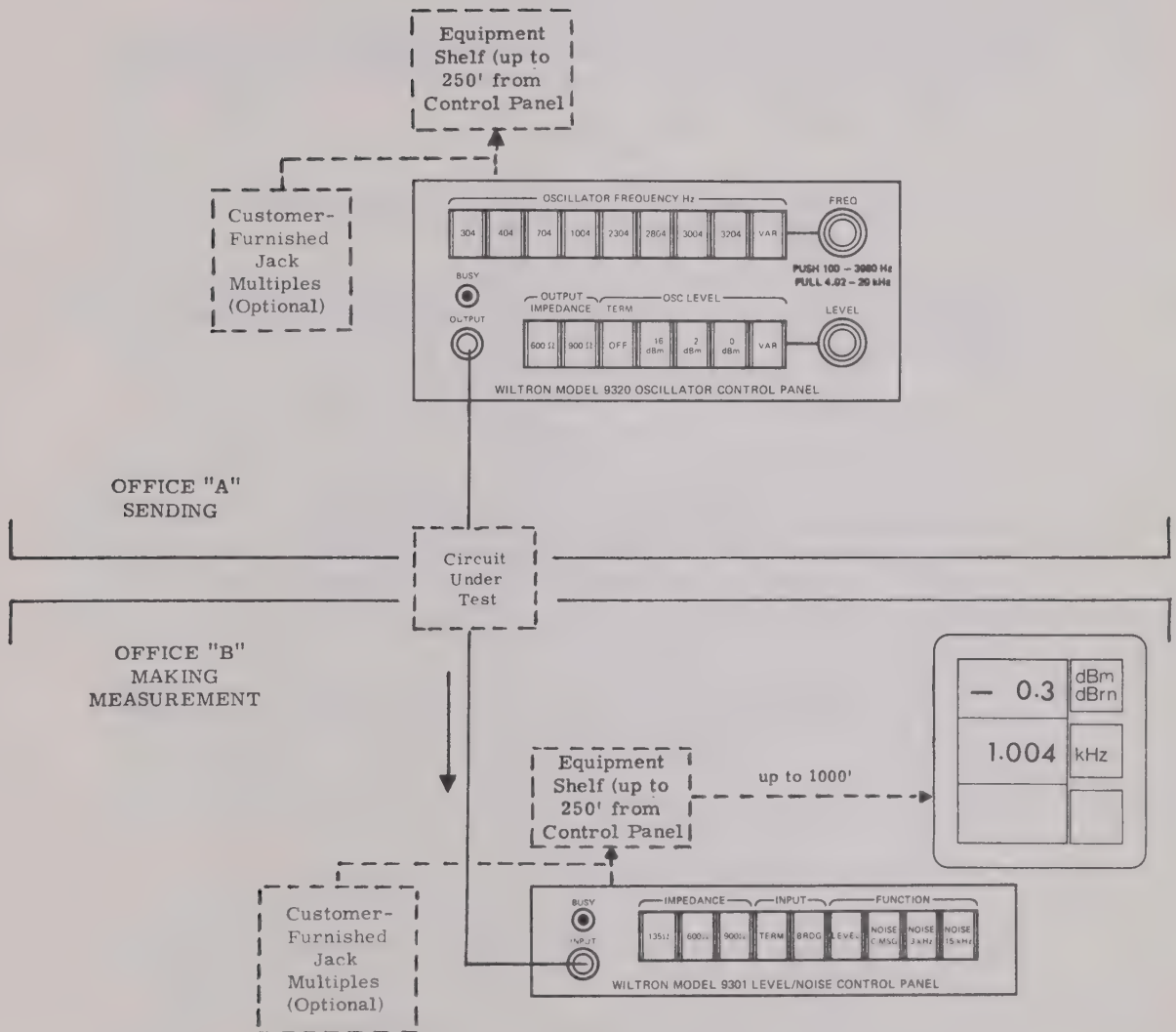


Figure 4-3. Typical Test Setup for Frequency Response (Attenuation Distortion) Measurements

FREQUENCY RESPONSE (ATTENUATION DISTORTION) MEASUREMENTS
USING LOCAL DTMS OSCILLATOR

STEP	PROCEDURE
1	Patch from the input of the circuit or device under test to the OUTPUT jack on the Oscillator Control Panel.* See Figure 4-3 for test setup.
2	Connect the output of the circuit or device under test to measure the test signal level as described in Section II.
3	If the BUSY indicator is lit at either the Oscillator or Level/Noise test locations, wait until the light goes out before making measurements .
	<u>NOTE</u> When the BUSY indicator is lit, the function is being used at another test location.
4	Press the desired OSCILLATOR FREQUENCY Hz pushbutton. If the VAR pushbutton is selected, adjust the FREQ. control for the desired test signal frequency.
5	Press the desired OUTPUT IMPEDANCE pushbutton.
6	Press the desired OSC LEVEL pushbutton. If the VAR pushbutton is selected, adjust the LEVEL control for the desired test signal level.
7	Press the LEVEL pushbutton on the Level/Noise Control Panel. Select the appropriate IMPEDANCE and INPUT pushbuttons. Note the readout of the Level Display at the output of the device or circuit under test.
8	Repeat steps 4 and 7 to obtain measurements over the frequency range of interest. *Refer to paragraph 4.01(A) for customer-furnished jack and lamp multiples.

OSCILLATOR PERFORMANCE VERIFICATION/CALIBRATION

STEP	PROCEDURE
1	Connect the Fluke 931B rms voltmeter to the OUTPUT jack on the Oscillator Control Panel using the test cable and adapter described in paragraph 4.03.
2	Connect a 600 ohm resistor (0.1% tolerance) across the adapter to provide a termination for the Oscillator.
3	Press the 1004 OSCILLATOR FREQUENCY pushbutton on the Oscillator Control Panel. Press the 600 Ω IMPEDANCE and the VAR OSC LEVEL pushbuttons.
4	Set the LEVEL control maximum clockwise, then back off one-quarter turn.
5	Set the rms voltmeter digits to 2.450 (10V range) and check for a null within 1%.
6	Check that the BUSY indicator at the Oscillator test location is not lit. If necessary, adjust the OUTPUT LEVEL ADJ. control on the front panel of the Oscillator module (in the CME Shelf) for a null on the rms voltmeter. This is equivalent to a +10 dBm output level.
<u>NOTE</u> This control is also used to provide calibration offset. See paragraphs 1.06(A) and 1.06(B) in Section I.	
7	Set the rms voltmeter digits to 0.77460 (1V range) and check for a null within 1% (equivalent to 0 dBm at 600 ohms).
8	Check that the BUSY indicator for the Oscillator is not lit. If necessary, adjust the LEVEL 3 control (screwdriver adjust) at the rear of the Oscillator Control Panel for a null on the rms voltmeter.
9	Press the -2 dBm OSC LEVEL pushbutton on the Oscillator Control Panel.
10	Set the rms voltmeter digits to 0.6150 (equivalent to -2 dBm at 600 ohms), and check for a null reading.
11	If necessary, adjust the LEVEL 2 control at the rear of the Oscillator Control Panel to obtain a null.
12	Press the -16 dBm OSC LEVEL pushbutton on the Oscillator Control Panel.
13	Set the rms voltmeter digits to 0.1227 (equivalent to -16 dBm at 600 ohms), and check for a null on the rms voltmeter.
14	If necessary, adjust the LEVEL 1 control at the rear of the Oscillator Control Panel to obtain a null.

OSCILLATOR PERFORMANCE VERIFICATION/CALIBRATION (CONT.)

STEP	PROCEDURE
15	Disconnect the 600 ohm resistor from the adapter, and connect a 900 ohm (0.1% tolerance) resistor as a termination.
16	Press the 900 Ω OUTPUT IMPEDANCE and the 0 dBm OSC LEVEL push-buttons on the Oscillator Control Panel.
17	Set the rms voltmeter digits to 0.9486 (equivalent to 0 dBm at 900 ohms). Check for a null reading on the voltmeter.
18	If necessary, adjust the 900 Ω LEVEL ADJUST control at the rear of the Oscillator Control Panel for a null.
19	Disconnect the rms voltmeter from the INPUT jack on the Oscillator Control Panel and connect the frequency counter (without the adapter and termination).
20	Press each OSCILLATOR FREQUENCY pushbutton in turn and, if necessary, adjust the corresponding control at the rear of the Oscillator Control Panel for a reading on the frequency counter within ± 1 Hz of the pushbutton label frequency.
21	Press the OSCILLATOR FREQUENCY VAR pushbutton. Pull out the FREQ control and set it to the maximum counterclockwise position. Check for a readout of 4020 Hz on the frequency counter.
22	If necessary, adjust the 4020 Hz HI BAND SET control at the rear of the Oscillator Control Panel.
23	Press in the FREQ control and set it to the maximum clockwise position. Check for a readout of 3980 Hz on the frequency counter.
24	If necessary, adjust the 3900 Hz LO BAND SET control at the rear of the Oscillator Control Panel.
<u>NOTE</u> The adjustments made in steps 22 and 24 ensure that the Oscillator does not transmit any frequency between 3980 and 4020 Hz. A tone in this frequency range could cause interference on Type N3 Carrier facilities.	
25	Set the FREQ control to the maximum counterclockwise position. Check that the control is pushed in for the low band selection. Check for a readout of 100 Hz on the frequency counter.
26	If necessary, adjust the 100 Hz LO BAND SET control at the rear of the Oscillator Control Panel.
27	Disconnect the test equipment.

4.04 THEORY OF OPERATION

The Oscillator measuring function circuits are contained on one PC board in the Measuring Module and on two PC boards in the Control Panel. The interface connections between the three PC boards are shown in the functional block diagram, Figure 4-4. When the oscillator output frequency is selected, a control voltage is applied to a buffer stage through the OFF switch (if not selected). A different control voltage is produced for each frequency, ranging between 0 and -5.8V. The control voltage is applied to two current sources, designated negative current value I and positive current value 2I. Each current source is fed through a buffer to a ramp generator. The current to the ramp generator is switched by two diode switches so that a ramp voltage (sawtooth waveform) is developed. To obtain the switching signal which drives the diode switches, the ramp generator output is squared by a Schmitt trigger and fed through an inverter/switch driver to the switching diodes. The ramp generator output is also applied through a shaper driver

to a shaping network which converts the sawtooth waveform to a sinewave. The sinewave is fed through a coax driver to a circuit in the Control Panel which converts the taper of the OUTPUT LEVEL ADJ. potentiometer from a linear to a logarithmic response. The output is then fed back to a low pass filter in the measuring module. The output amplifier provides the stability and response characteristics to ensure a balanced output at the selected impedance. The Oscillator level selection determines the amplitude of the output signal fed through the low pass filter to the output amplifier.

4.05 TROUBLESHOOTING

Table 4-3 is a troubleshooting chart for the Oscillator function. The Signal Flow Charts, Figures 4-5 and 4-6, may also be used to assist in troubleshooting. The only equipment required for this procedure is a DC Voltmeter, Simpson 260 or equivalent.

Table 4-3. Oscillator Troubleshooting Chart

STEP	PROCEDURE	ACTION	
		IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
1.	a. Switch the system power on. Press the 600 μ , 0 dBm, and 1004 Hz push-buttons on the Oscillator Control Panel.	Proceed with step 2.	Oscillator PC Board 9220 is faulty.
	b. Check that the dc voltage between terminals B and D (common) on terminal strip TS2 at the rear of the Oscillator Control Panel is approximately -6.2V.		

Table 4-3. Oscillator Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
2.	Check that the dc voltage between terminals F and D on terminal strip TS2 is approximately 1.45 V.	Proceed with step 3.	PC Board 9300-ML-1005 in the Oscillator Control Panel is faulty.
3.	Check that approx. 1.5 V ac is present at terminals C and D (common) on terminal strip TS2 at the rear of the Oscillator Control Panel.	Proceed with step 4.	Oscillator PC Board 9220 is faulty.
4.	Check that approx. 0.4 V ac is present at terminals E and D on terminal strip TS2.	Proceed with step 5.	PC Board 9300-ML-1006 in the Oscillator Control Panel is faulty.
5.	Check that approx. 0.7 V ac is present between terminals N and P (common) on terminal strip TS2.	Proceed with step 6.	Oscillator PC Board 9300-ML-1006 is faulty.
6.	Check that approx. 0.7 V ac is present between terminals L and K (common) on terminal strip TS1.	Check contacts of OUTPUT jack on the Oscillator Control Panel.	Oscillator PC Board 9300-ML-1006 is faulty.

4.06 REMOVAL AND REPLACEMENT

Following are instructions for removing and replacing PC Boards 9300-ML-1005 and 9300-ML-1006 in the Oscillator Control Panel.

(A) PC Board 9300-ML-1005

Remove and replace the PC Board as follows:

1. Switch the system power off.
2. Loosen the two screws which secure the Oscillator Control Panel to the system front panel. Move the Control Panel backwards to gain access to the cover screws on top.
3. Remove four screws from the cover, then pull it straight back to detach the cover from the Oscillator Control Panel.
4. Loosen the setscrew which secures the knob on the FREQ control. Remove the knob from the control shaft. Remove the hex nut which secures the control to the front panel.
5. Remove the retaining ring which secures the BUSY indicator to the Control Panel. Push the indicator backwards to detach it from the Control Panel.
6. Remove one screw to detach the OUTPUT jack from the Control Panel.
7. Remove the PC Board and attached parts from the Control Panel.

NOTE

The BUSY indicator, FREQ control, and OUTPUT jack are hardwired to the PC Board.

8. Position the new PC Board in the Control Panel so that the pushbutton switches and the shaft of the FREQ

control extend through the front panel.

9. Secure the FREQ control to the front panel with the hex nut. Push in the FREQ control shaft, then place the knob on the shaft and secure it by tightening the setscrew.
10. Secure the OUTPUT jack to the front panel with one screw.
11. Press the BUSY indicator through the grommet in the front panel and secure it with the retaining ring.
12. Place the cover on the Oscillator Control Panel, ensuring that the PC Board connectors are properly plugged into the sockets on the cover. Secure the cover with four screws.
13. Move the Oscillator Control Panel forward so that the front panel is flush with the system front panel. Secure the Oscillator Control Panel using the screw and tab at each side.

(B) PC Board 9300-ML-1006

Remove and replace the PC Board as follows:

1. Gain access to the inside of the Oscillator Control Panel as described in steps 1 through 3 in paragraph 4.06(A) above.
2. Loosen the setscrew which secures the knob on the LEVEL control. Remove the hex nut which secures the control to the front panel.
3. Remove the PC Board and the attached LEVEL control from the Control Panel.
4. Position the new PC Board in the Control Panel, with the pushbutton switches and the shaft of the LEVEL control extending through the front panel.
5. Secure the LEVEL control to the front panel with the hex nut. Place the knob on the shaft and secure it by tightening

Parts List

the setscrew.

6. Attach the equipment covers as described in steps 12 and 13 in paragraph 4.06(A).

4.07 PARTS LIST

Table 4-4 lists the WILTRON part numbers for the replaceable assemblies used with the Oscillator function.

Table 4-4. Parts List for Oscillator Equipment

<u>DESCRIPTION</u>	<u>WILTRON PART NO.</u>
Oscillator Control Panel	9320
PC Board, Frequency	9300-ML-1005
PC Board, Level	9300-ML-1006
Oscillator Measuring Module	9220

4.08 FUNCTIONAL BLOCK DIAGRAM

Following is a functional block diagram of the Oscillator function.

4.09 SIGNAL FLOW CHART

The Signal Flow Chart, Figure 4-5, can be used for troubleshooting the Oscillator measurement function, and may also be used when checking the cabling connections between the Control Panel, Equipment Shelf, and Display Housing.

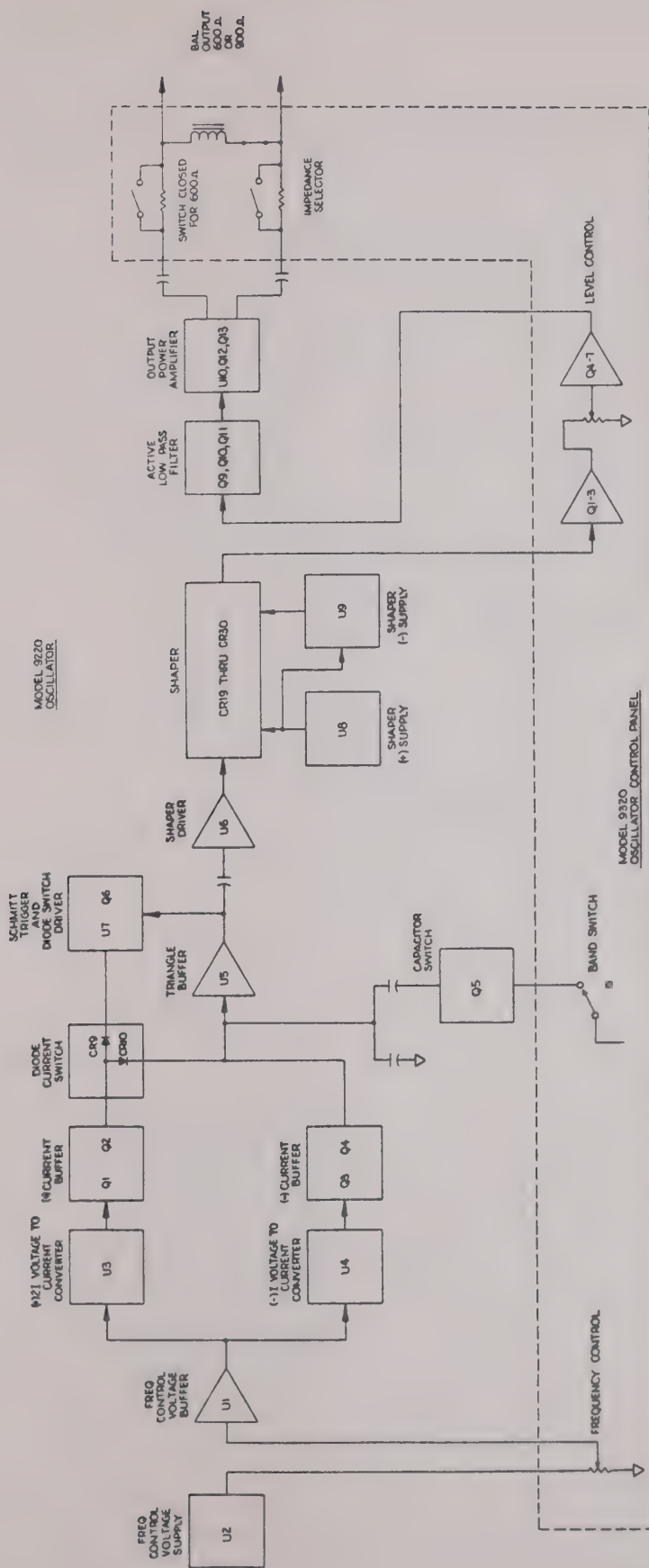
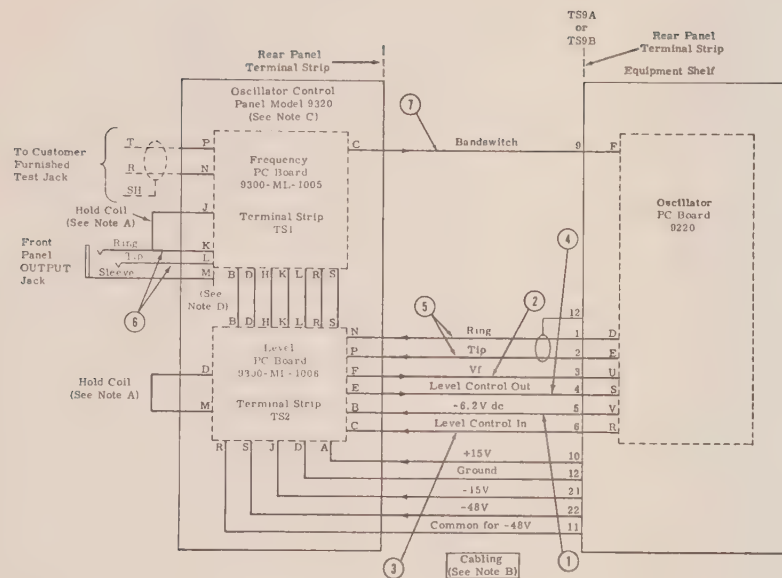


Figure 4-4. Oscillator Functional Block Diagram



NOTES

- Strap to provide hold coil across tip and ring for off-hook supervision on 2-wire outgoing trunks.
- Cabling between Control Panel and Equipment Shelf may be up to 250 ft. long.
- See next sheet for Oscillator Control Panel Model 9321.
- Jumper connections between PC boards is made at rear panel terminal strips.
- Check that Power Supply is serviceable before troubleshooting the Oscillator function. See Sections IX and X of this manual.

TERMINAL DESIGNATIONS

CONTROL PANELS AND DISPLAYS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

(Terminals G, I, O, and Q omitted)

EXTENDER BOARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V

(Terminals G, I, O, and Q omitted)

HOW TO USE THE CHART

- Use a VOM for the measurements.
- Make the checks in the order shown below. If a particular voltage is abnormal, but the previous measurements are normal, it is likely that the PC Board between these two points is faulty.
NOTE: On new installations, the cabling should be checked first for wiring errors.
- If a spare PC Board of the same model is available, it can be substituted for the suspect board to see if the fault is cleared.

TROUBLESHOOTING CHECKS

TEST POINT	READING	REMARKS
① (Not 1)	-6.2 V dc approx. to common (TS9-18)	Controls selected 600 μ , 0 dBm, 1004 Hz
②	1.45 V dc approx. to common (TS9-18)	Same as above.
③	1.5 V ac approx. to common (TS9-12)	Same as above.
④	0.4 V ac approx. to common (TS9-12)	Same as above.
⑤	0.7 V ac approx. to common (TS9-12)	Same as above.
⑥	Same as above.	Same as above.
⑦	+5 V dc approx. to common (TS9-18) 0 V dc approx. to common (TS9-18)	For 100 Hz - 4 kHz range. For 4 kHz - 20 kHz range.

Figure 4-5. Oscillator Signal Flow Chart for Model 9320

NOTE

The Return Loss instructions are divided into Sections V and V(A). Section V covers 4-Wire measurements using the Model 9310 Return Loss Control Panel. Section V(A) is used in addition to Section V for 2- or 4-Wire measurements using the Model 9311 Return Loss Control Panel in conjunction with the Model 9310 Control Panel.

SECTION V

ECHO RETURN LOSS AND SINGING POINT
MEASUREMENT FUNCTION

SECTION V	CONTENTS	PAGE
5.	GENERAL.	5-1
5.01	DESCRIPTION OF FUNCTION	5-1
5.02	OPERATING PRO- CEDURES.	5-2
	(A) Function of Controls, Indicators, and Connectors	5-2
	(B) Return Loss Display	5-3
	(C) Return Loss Opera- tional Check.	5-3
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5. GENERAL

5.01 DESCRIPTION OF FUNCTION
The Return Loss Control Panel contains front panel pushbuttons for selection of three Return Loss Test Type signals defined as:

ERL (Echo Return Loss)

SRL LO (Singing Return Loss Low)

SRL HI (Singing Return Loss High)

Figure 5-1 shows the shape and bandwidth limits of the three test signals. A fourth pushbutton, marked EXT OSC is used to select an external oscillator (connected via rear panel wire wrap terminals) for the test signal. Three digital switches on the Control Panel are used for Transhybrid Loss correction, thus permitting a direct Return Loss readout without calculation. A front panel key (marked TEST LEVEL POINT) is provided to select transmit and receive test signals at 0 or -16 and +7 points for Return Loss measurements on carrier channels.

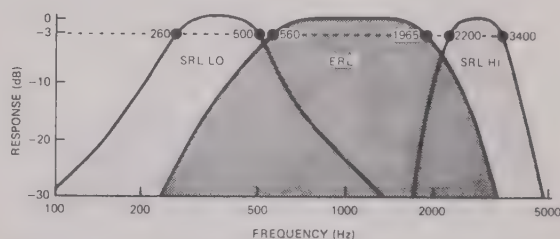


Figure 5-1. Bandwidth of Return Loss Test Type Signals

Return Loss measurements are made through the TRMT and RCV jacks on the front panel. The Echo Return Loss and Singing Point function can also be used through customer-furnished jack multi-plates for test signal connections. The desired number of jacks are connected in parallel with the TRMT and RCV jacks through the wire wrap terminals at the rear of the panel. The BUSY indicators can be wired to light at all test locations except the location being used. Selection of the Return Loss test type, THL correction,

Specifications

and test level point must be made at the Control Panel. For detailed instructions for incorporating any of the options described above, refer to the WILTRON Engineering Information Manual.

The Return Loss Display can be installed in a display housing with the Level/Noise, Frequency, or Multimeter Cable Analyzer displays (see Figure 1-1 in Section I). The Return Loss Measurement module consists of three PC Boards (Models 9210-1, 9210-2, and 9210-3) installed in the Equipment Shelf in addition to the Timer Module. Specifications for the Echo Return Loss and Singing Point measurement function are provided in Table 5-1.

Table 5-1. Specifications for Echo Return Loss and Singing Point Measurement Function

TRANSMITTER

OUTPUT LEVEL: Switch Selectable
-2 dBm $\pm$ 0.2 dB or -18 dBm $\pm$ 0.3 dB.

TEST SIGNALS

WHITE NOISE, band limited by three filters as described below, controlled by illuminated pushbuttons.

ECHO RETURN LOSS: 560 - 1965 Hz
(-3 dB).

SINGING RETURN LOSS LOW: 260 -
500 Hz (-3 dB).

SINGING RETURN LOSS HIGH: 2200 -
3400 Hz (-3 dB).

VARIATION IN POWER LEVEL WHEN
SWITCHING FILTERS: $\pm$ 0.1 dB max.

RECEIVER

RETURN LOSS MEASUREMENT RANGE:
-9.9 dB (+9.9 return gain) to 52 dB.

RESOLUTION: 1 dB.

OVERALL ACCURACY: $\pm$ 1 dB to 40 dB;
 $\pm$ 2 dB to 50 dB return loss.

READING UPDATE RATE: 2-1/4
times per second.

TRANS-HYBRID LOSS CORRECTION
RANGE: 0 to 29.9 dB in 0.1 dB
steps.

INTERFERENCE PROTECTION
FILTER: Bandpass 200 - 5000 Hz.
Rejects below 60 Hz and above 56
kHz >40 dB. The filter is included
as a standard part.

GENERAL

INPUT AND OUTPUT IMPEDANCE is
600 ohms with 30 dB minimum re-
turn loss using the ERL or SRL
spectrums.

LONGITUDINAL BALANCE: exceeds
50 dB from 50 Hz to 6 kHz.

LONGITUDINAL VOLTAGE PROTEC-
TION: up to 30V rms at 60 Hz,
while meeting accuracy specifica-
tion.

TRANSIENT VOLTAGE PROTECTION:
up to 600V having 10 microsecond
rise time and 1200 microsecond
decay time across TRMT or RCV
terminals.

5.02 OPERATING PROCEDURES

(A) Function of Controls, Indicators,
and Connectors

Table 5-2 describes the function of the
controls, indicators, and connectors on
the Return Loss Control Panel.

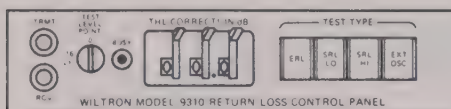


Figure 5-2. Return Loss Control Panel

Table 5-2. Function of Controls, Indicators, and Connectors.

BUSY: Light emitting diode indicator lamp. When the indicator is not lit, the Return Loss measurement equipment is available for use. When the indicator is lit, the Return loss measurement equipment is being used at another test location.

TEST LEVEL POINT: Two-position key.

In the 0 position, the transmit and receive signals are at a zero transmission or test level point (0 TLP).

In the $\frac{-16}{+7}$ position the transmit and receive signals can be used at a -16 and +7 point, respectively.

TRMT and RCV: Western Electric type 310 jacks (other type jacks optional). When plugs are inserted in the jacks, the Return Loss measurement equipment is accessed if the BUSY indicator is not lit. The transmission level point (TLP) of signals at the TRMT and RCV jacks is determined by the setting of the TEST LEVEL POINT switch. See paragraph 5.01 for jack multiple options.

TEST TYPE: Four back-lighted push-button switches. Provides selection of one of three shaped (weighted) noise spectra, or a customer-furnished external source for the transmit signal. The three shaped noise signals (see Figure 5-1) are as follows:

ERL (Echo Return Loss): 560 to 1965 Hz

SRL LO (Singing Return Loss Low):
260 to 500 Hz

SRL HI (Singing Return Loss High):
2200 to 3400 Hz

The EXT OSC selection can be used for structural return loss measurements if a suitable oscillator is used with the Return Loss measurement equipment.

THL CORRECTION dB: One 3-position and two 10-position digital lever switches. Used to compensate for loss through the external connected hybrid circuit when making Return Loss measurements. Compensation from 0 to 29.9 dB in 0.1 dB steps is provided.

(B) Return Loss Display



Figure 5-3. Return Loss Display

The Return Loss Display (see Figure 5-3) is a digital display used with the Return Loss Control Panel. It displays the Return Loss reading to the nearest dB. The range of measurement is from -10 dB (+10 dB return gain) to +52 dB return loss. Digit blanking occurs for underrange and overrange conditions. A + sign is displayed for an underrange condition, and a - sign for an overrange condition.

(C) Return Loss Operational Check

The following procedure should be performed periodically to ensure that the Echo Return Loss and Singing Point measurement function is operating properly.

OPERATIONAL CHECK

STEP	PROCEDURE						
1	Patch from the TRMT jack to the RCV jack on the Return Loss Control Panel. *						
2	Set the panel controls as follows: <table> <tr> <td>TEST TYPE</td><td>ERL</td></tr> <tr> <td>THL CORRECTION dB</td><td>00.0</td></tr> <tr> <td>TEST LEVEL POINT</td><td>0</td></tr> </table>	TEST TYPE	ERL	THL CORRECTION dB	00.0	TEST LEVEL POINT	0
TEST TYPE	ERL						
THL CORRECTION dB	00.0						
TEST LEVEL POINT	0						
3	Check that the BUSY indicator is not lit, then check that the Return Loss Display is approximately 0 dB. **						
4	Set the TEST LEVEL POINT key to the $\frac{-16}{+7}$ position. Check that the Return Loss Display is approximately +23 dB. **						
5	Set the THL CORRECTION dB switches to 23.0 dB. Check that the Return Loss Display readout is 0±1 dB. Remove the patch.						
	*Measurements may also be made through customer-supplied jack multiples. Refer to paragraph 5.01 for information regarding this option. **A 0 dB or +23 dB reading will not be obtained if calibration offset has been introduced in the Common Measurement Equipment to allow for cable losses or TP2 offset in your office. Refer to paragraph 1.06 in Section I.						

(D) Through Balance (Echo Return Loss, and Singing Return Loss Measurements)

Through balance is the process of averaging the Echo Return Loss (ERL) and Singing Return Loss (SRL) measurements made at all combinations of intertoll through paths in Class 3 and higher offices. These measurements involve the office equipment and 4-wire to 4-wire paths only. The objective of through balancing is to match the 2-wire impedance of the 4-wire terminating sets of incoming trunks to that of outgoing trunks on a uniform basis regardless of the connection path used in 2-wire switching offices.

Through balance involves Return Loss measurements over three selectable bandwidths defined as ERL (Echo Return Loss), SRL LO (Singing Return Loss Low), and SRL HI (Singing Return Loss High). The bandwidths covered by the three test signals are shown in Figure 5-1.

The ERL test signal closely compares with that of the combined weighting (shaping) provided by a Western Electric Type 201 Noise Generator and Type 455B and 497A "C" message weighting filters.

The test signals for the SRL LO and SRL HI bands give Return Loss measurements that are equivalent to Singing Point measurements made with a Western Electric Type 2D Singing Point Test Set and an external Type 207G High Pass Filter. Measurements are made to Bell System specification number KS20501.

When making Singing Return Loss measurements, the Return Loss in dB is measured for the SRL LO and SRL HI bands. The Band which provides the lowest Return Loss reading is the frequency range in which singing is most likely to occur.

Some typical causes of low ERL and SRL LO readings are:

1. Defective or incorrectly strapped 4-wire terminating sets.
2. Hybrids or 4-wire terminating sets of incorrect impedance ratio.
3. Impedance compensators improperly adjusted, or cross-connected with input and output transposed.
4. Incorrect or double termination at distant end.
5. Repeat coils incorrectly wired, or with incorrect value midpoint capacitors.
6. Excessive circuit noise.

Typical causes of a low SRL HI reading are:

1. Incorrect value of NBO or DBO capacitors.
2. Office wiring incorrect, is too long, or has side taps to distant equipment.
3. Improper circuit terminations, hybrids, trunk equipment impedance ratios or strapping.
4. Excessive circuit noise.

(E) Terminal Balance (Echo Return Loss, and Singing Return Loss Measurements)

Terminal balance consists of matching the 2-wire impedance of the 4-wire terminating sets of the intertoll trunks with the impedance of the toll connecting trunks (usually 2-wire). Terminal balance involves office equipment and wiring in toll offices connecting to test terminations in end offices. The objective of terminal balance is to obtain a transmission quality for the toll office that permits it to switch intertoll trunks at Via Net Loss (VNL) level to toll connecting trunks at VNL +2 dB.

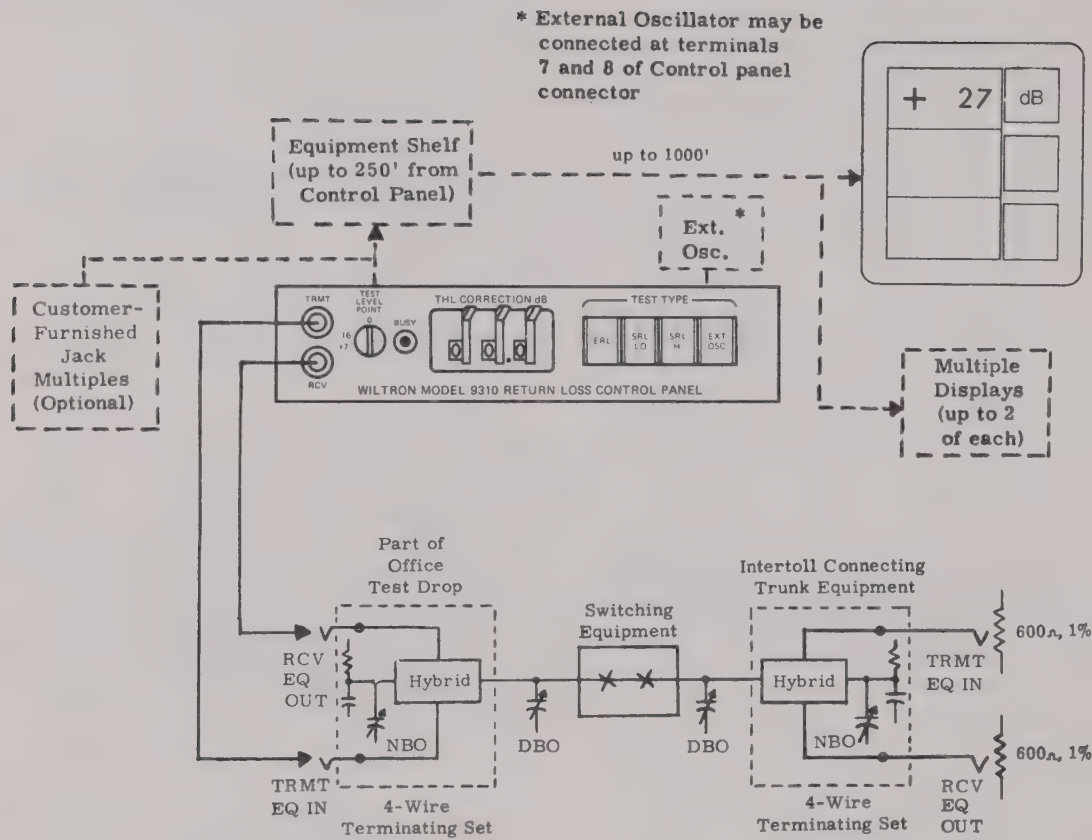


Figure 5-4. Typical Test Setup for Through Balance, Echo Return Loss, and Singing Return Loss Measurements

THROUGH BALANCE (ECHO RETURN LOSS, AND SINGING POINT MEASUREMENTS)

STEP	PROCEDURE
1	Establish a connection (drop dial) through the office to an intertoll connecting trunk under test, using the office test hybrid and associated drop equipment (see Figure 5-4).
2	After the outgoing trunk has been identified, terminate the drop side of the 4-wire hybrid arms of the trunk under test with 600 ohm, $\pm 1\%$ or better terminating plugs.
3	Patch from the TRMT and RCV jacks on the Return Loss Control Panel to the office test hybrid TRMT and RCV jacks (4-wire arms). *
4	Check that the TEST LEVEL POINT key is set to 0, and the THL CORRECTION dB switches are set to 00.0.
5	If the BUSY indicator is lit for the Return Loss function, wait until the light goes out.
<u>NOTE</u> When the BUSY indicator is lit, the Return Loss measurement function is being used at another test location.	
6	Press the ERL pushbutton on the Return Loss Control Panel. Adjust the THL CORRECTION dB switches for the amount of trans-hybrid loss through the office test hybrid. If this value is unknown, apply an open or short circuit condition on the 2-wire side of the office test hybrid, then adjust the THL CORRECTION dB switches until the Return Loss Display reads zero dB.
7	Remove the open or short from the 2-wire side and read the Return Loss directly in dB. The reading obtained is the Echo Return Loss (ERL) of the office Through Balance measurement to the intertoll connecting trunk.
8	Press the SRL LO pushbutton and record the reading obtained.
9	Press the SRL HI pushbutton and record the reading obtained.
10	The lowest (worst case) of the two readings obtained in steps 8 and 9 is the Singing Point of the connection under test. **
11	Repeat steps 1 through 10 for all combinations of intertoll through paths in the office to obtain average office balance readings.
12	To optimize the Return Loss readings obtained in steps 7 through 11, refer to individual Plant Practices on Through Balance describing NBO and DBO adjustments and compromises.
*Refer to paragraph 5.01 for customer-furnished jack multiple options.	
**Refer to paragraph 1.06 in Section I for calibration offset of the Return Loss measurement function.	

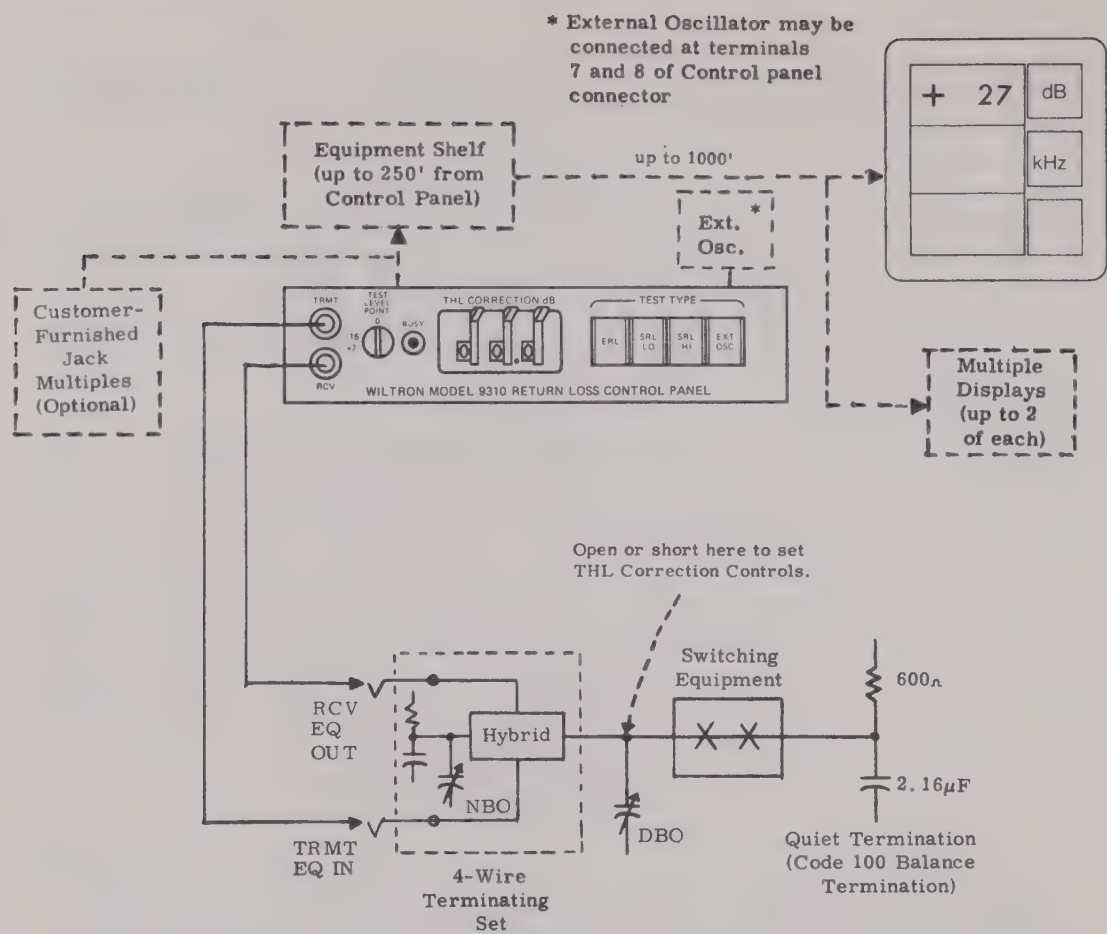


Figure 5-5. Typical Test Setup for Terminal Balance, Echo Return Loss, and Singing Return Loss Measurements

TERMINAL BALANCE (ECHO RETURN LOSS, AND SINGING POINT MEASUREMENTS)

STEP	PROCEDURE
1	Using the representative office hybrid and associated drop equipment, establish a connection through the office (drop dial) to the office termination number or to a toll connecting trunk capable of accessing a <u>balance</u> termination number (see Figure 5-5). <u>NOTE</u> The office test termination is also referred to as a quiet termination number, and is assigned as Code 100 in many common control offices.

TERMINAL BALANCE (ECHO RETURN LOSS, AND SINGING POINT
MEASUREMENTS (CONT.))

STEP	PROCEDURE
2	Patch from the TRMT and RCV jacks on the Return Loss Control Panel to the office test hybrid TRMT and RCV jacks (4-wire arms).*
3	Check that the TEST LEVEL POINT key is set to 0, and the THL correction dB switches are set to 00.0.
4	If the BUSY indicator is lit for the Return Loss function, wait until the light goes out.
	<u>NOTE</u> When the BUSY indicator is lit, the Return Loss measurement function is being used at another test location.
5	Press the ERL pushbutton on the Return Loss Control Panel. Adjust the THL CORRECTION dB switches for the amount of trans-hybrid loss through the office test hybrid. If this value is unknown, open or short circuit the 2-wire side of the office test hybrid, then adjust the THL CORRECTION dB switches until the Return Loss Display reads zero dB.
6	Remove the open or short from the 2-wire side and read the Return Loss directly in dB. The reading obtained is the Echo Return Loss (ERL) of the toll connecting trunk under test.
7	Press the SRL LO pushbutton and record the reading obtained.**
8	Press the SRL HI pushbutton and record the reading obtained.**
9	The lowest (worst case) of the two readings obtained in steps 7 and 8 is the Singing Point of the connection under test.
10	Repeat steps 1 through 9 for all remaining combinations of toll connecting trunk paths in the office.
11	To optimize the Return Loss readings obtained in steps 6 through 10 refer to individual Plant Practices on Terminal Balance describing NBO and DBO adjustments and compromises.
	*Refer to paragraph 5.01 for customer-furnished jack multiple options. **Refer to paragraph 1.06 in Section I for calibration offset of the Return Loss measurement function.

Carrier Channel Measurements

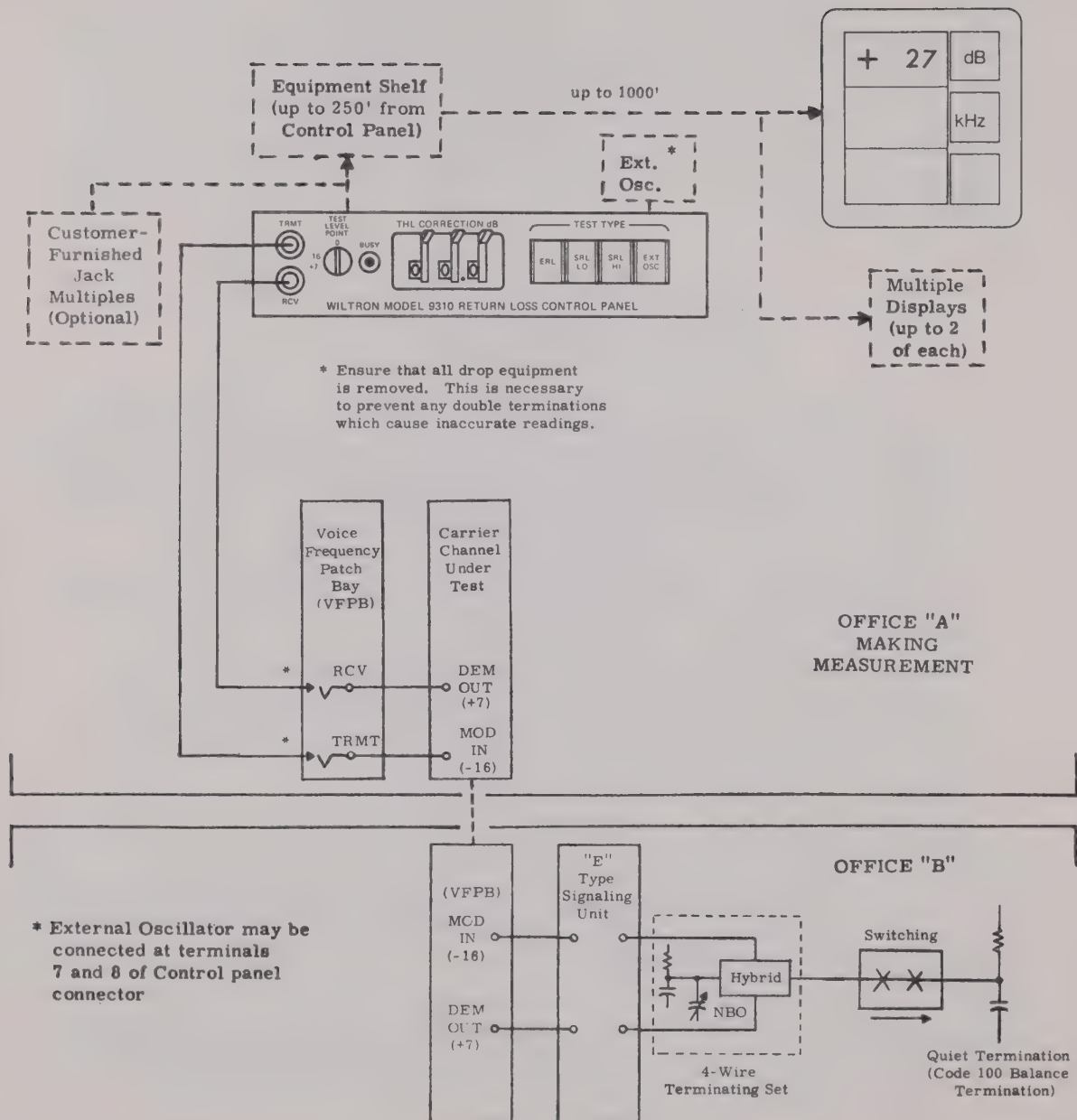


Figure 5-6. Typical Test Setup for Carrier Channel Echo Return Loss and Singing Return Loss Measurements

CARRIER CHANNEL ECHO RETURN LOSS AND SINGING RETURN LOSS MEASUREMENTS

STEP	PROCEDURE
1	Line dial the circuit under test to the balance termination in the distant office. <u>NOTE</u> The balance termination is also referred to as a quiet termination number, and is assigned as Code 100 in many common control offices.
2	Connect the equipment as shown in Figure 5-6.
3	Press the ERL pushbutton. Set the TEST LEVEL POINT key to the $\frac{-16}{+7}$ position.
4	If the BUSY indicator is lit at the Return Loss test location, wait until the light goes out. <u>NOTE</u> When the BUSY indicator is lit, the Return Loss Measurement function is being used at another test location.
5	Have the distant office place a short on the 2-wire side of the hybrid for the circuit under test. While the short is applied, adjust the THL dB decades for a 0 dB reading on the Return Loss Control Panel. Remove the short.
6	Measure the Echo Return Loss (ERL). Note the ERL reading.*
7	Measure the Singing Return Loss High (SRL HI) and Singing Return Loss Low (SRL LO), with the appropriate TEST TYPE pushbutton pressed. Note the two readings. The lowest of these readings is the Singing Point of the circuit.
8	Compare the readings obtained in steps 6 and 7 with the Terminal balance measurements previously made in the distant office to determine if the associated carrier channel degrades the ERL, SRL HI, or SRL LO readings.
9	Repeat steps 1 through 8 for the remaining carrier channels in the office. *Refer to paragraph 1.06 in Section I for calibration offset of the Return Loss measurement function.

The test signals used for Terminal Balance are the same as described for Through Balance in paragraph (D).

(F) Carrier Channel Return Loss and Singing Return Loss Measurements

The Return Loss Control Panel provides a TEST LEVEL POINT key that can be set to introduce 23 dB of loss for making Return Loss measurements over carrier channels. The TRMT jack provides a test signal that is attenuated by 16 dB. The RCV jack attenuates the carrier channel voice output by 7 dB. This feature facilitates making a measurement toward a distant office to determine the quality of the connected channel, trunk, and office equipment for ERL and Singing Point objectives. In practice, a connection is established to another office over a carrier channel and Return Loss readings taken. The reading should comply with ERL and Singing Point objectives for the distant office. If the readings are below specifications, the far end Mod and Demod channel voice access points can be split (term-

inated) to determine whether the carrier channel is at fault or the far office has balance problems. A typical test setup for carrier channel Return Loss measurements is shown in Figure 5-6 on page 5-10.

5.03 PERFORMANCE VERIFICATION/CALIBRATION

The performance verification/calibration procedure enables the user to verify that the Echo Return Loss and Singing Point measurement function meets the design specifications. This procedure may be performed upon installation of the equipment (prior to use), periodically, or when failure of the measurement function is suspected.

The calibration has been set at the factory to provide a true return loss reading (refer to paragraph 1.06(B) and (C) and the Return Loss adjustment procedures for offset information). The following test equipment (or equivalent) is required for this procedure.

- a. HP236A Audio Oscillator
- b. Fluke 931B RMS Voltmeter

PERFORMANCE VERIFICATION/CALIBRATION PROCEDURE

STEP	PROCEDURE
1	Connect the audio oscillator output to the RCV jack on the Return Loss Control Panel. Connect the Fluke 931B rms voltmeter to measure the audio oscillator output.
2	Switch the power off at the Power Supply in the Equipment Shelf. Remove PC Board 9210-2 from the Equipment Shelf. Mount the PC Board on the extender board (stored behind the Timer) then install the extender board in the slot.
3	Switch the Equipment Shelf power on. Set the audio oscillator controls for a 1 kHz 0 dBm output at 600 ohms. Press the ERL pushbutton on the Return Loss Control Panel. Set the TEST LEVEL POINT key to 0 and the THL CORRECTION switches to 00.0.
4	Slowly decrease the audio oscillator output level until the Return Loss Display readout is approximately +11.0 dB.

PERFORMANCE VERIFICATION/CALIBRATION PROCEDURE (CONT.)

STEP	PROCEDURE
5	Set the NORM/TEST slide switch to TEST.
6	Check that the Return Loss Display readout is approximately +1 dB. Adjust the audio oscillator output to obtain a +1 dB readout and simultaneously light the XX.0 CALIBRATION INDICATOR.
7	Set the NORM/TEST slide switch to NORM. Check that the Return Loss Display readout is +11 dB and that the XX.0 CALIBRATION INDICATOR on the PC Board front panel remains lit. If necessary, adjust LINEARITY control R9 for the correct display.
8	Switch the system power off. Remove the PC Board from the extender board. Install the PC Board in its slot. Switch the system power on.
9	Set the rms voltmeter digits to .6153V (equal to -2 dBm at 600 ohms) and to read a null within 1%.
10	Carefully adjust the audio oscillator output level for a null on the rms voltmeter. Check that the Return Loss Display readout is 0 dB.
11	If necessary, adjust the RCV CAL. control on the front panel of PC Board 9210-3 (in Equipment Shelf) for a 0 dB readout on the Return Loss Display.* Fine adjust the RCV CAL. control until the XX.0 CALIBRATION INDICATOR lamp on PC Board 9210-2 remains lit.
<u>NOTE</u> Complete steps 12 through 14 only when PC Board 9210-2 has been replaced or the proper results cannot be obtained for step 11.	
12	Patch from the +5V test point on the Power Supply front panel to the DET. OUTPUT test point on Return Loss Receiver PC Board 9210-3.
13	Check that the Return Loss Display readout is -10 dB and the XX.0 CALIBRATION INDICATOR on PC Board 9210-3 is lit. If necessary, adjust the A to D CAL. control on PC Board 9210-3 for the correct results.
14	Repeat steps 1 through 11.
*This control may be used for calibration offset. See paragraph 1.06 in Section I.	

5.04 THEORY OF OPERATION

(A) Transmitter Circuit

Refer to the Return Loss functional block diagram, Figure 5-7, at the end of this section. The Return Loss transmit signal is developed by a white noise generator which produces a noise output covering a wide frequency spectrum. The output of the noise generator is filtered to provide a test signal with a specific shape and bandwidth (see Figure 5-1), as selected by the Test Type pushbuttons. The filtered transmit signal is amplified and fed through a transformer to the trunk under test. The transformer is used to obtain a 600 ohm balanced output from the transmitter.

(B) Receiver and Display Circuits

The receive Return Loss signal is applied through a balanced attenuator and preamplifier to the THL gain circuits. The THL dB switches are set to provide an amplifier gain equal to the loss through the hybrid in the circuit under test. This permits a direct return loss reading without having to add the amount of transhybrid loss to the measured value.

The receive signal is fed through a noise protection filter to the autoranging circuits. The autoranging circuits automatically adjust the level of the test signal to be within the 10 dB range for the peak and average detectors.

A buffer amplifier follows the autoranging circuits. The output of the buffer amplifier is applied to two detectors. One of the detectors responds to the average value of the test signal level. The second detector responds to the peak value of the test signal level. Both detector outputs are applied to a summing and smoothing amplifier which also sets the Return Loss calibration. The output of the amplifier is a dc voltage with a magnitude proportional to the test signal level.

The dc output voltage from the summing and smoothing amplifier is applied to a comparator along with timing signals from the Timer to develop a digital signal that contains the test signal level information. The comparator output is processed by gating and sequence detection circuits to obtain the digital signals necessary to drive the counters. The BCD (binary coded decimal) outputs from the counters are decoded by the decoder/drivers located in the Return Loss Display Module. The outputs from the decoder/drivers cause the appropriate decimal digit to light in each display tube.

Additional digital logic circuits develop the control signals required to blank the display digits and light the appropriate polarity sign for an underrange or overrange condition.

5.05 TROUBLESHOOTING

Table 5-3 is a troubleshooting chart for the Return Loss measurement function. The Signal Flow Chart, Figure 5-8 can also be used to assist in troubleshooting. An audio oscillator (such as the Send Oscillator function), a noise measuring set (such as the Level/Noise measurement function), a 30 dB attenuator (600 ohm), and a multimeter (Simpson 260 or equivalent) are required for this procedure.

5.06 REMOVAL AND REPLACEMENT

The following procedure provides instructions for removing and replacing the PC Board in the Return Loss Control Panel.

Table 5-3. Return Loss Function Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	a. Connect the noise measuring set to the TRMT jack on the Return Loss Control Panel through the 30 dB attenuator.	a. Disconnect the noise measuring set.	PC Board 9210-1 in the Equipment Shelf is faulty.
	b. Check that the noise readout is approximately +60 dBrn.	b. Proceed with step 2.	
2.	a. Connect the audio oscillator to the RCV jack on the Return Loss Control Panel.	Proceed with step 3.	PC Board 9210-3 in the Equipment Shelf is faulty.
	b. Set the oscillator output for +5 dBm at 1 kHz.		
	c. Check that the THL dB CORRECTION switches on the Return Loss Control Panel are set to 00.0.		
	d. Check that the ac voltage between terminals 5 and D (common) on the Control Panel (or TS8-8 and 12 on the Equipment Shelf) connector is approximately 1.5V rms.		

Table 5-3. Return Loss Function Troubleshooting Chart (Cont.)

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
3.	Check that the ac voltage between terminals 6 and D (common) on the Control Panel (or TS8-9 and 12 on the Equipment Shelf) connector is approximately 1.5V rms.	Proceed with step 4.	PC Board in Return Loss Control Panel is faulty.
4.	Check that the dc voltage at the DET OUTPUT test point on the front of PC Board 9210-3 (in the Equipment Shelf) is approximately 3.3V.	Proceed with step 5.	PC Board 9210-3 in the Equipment Shelf is faulty.
5.	a. Switch the system power off. Unplug PC Board 9210-2 from the Equipment Shelf and mount it on the extender board. b. Plug the extender board into the slot for PC Board 9210-2. c. Switch the power on. Check that the BCD lines at the terminals of PC Board 9210-2 are at the correct logic levels for a -7 dB return loss reading. See the example (step ⑥) in the introduction to Figure 2-8 in Section II.	Return Loss Display Module is faulty.	PC Board 9210-2 in the Equipment Shelf is faulty.

PC BOARD REMOVAL AND REPLACEMENT

STEP	PROCEDURE
1	Remove the four screws from the cover of the Return Loss Control Panel. Remove the cover by pulling it straight back to detach the cover from the PC Board connectors inside the Control Panel.
2	Remove the retaining ring which secures the BUSY indicator to the front panel. Push the indicator backwards to remove it from the front panel.
3	Remove the screw that secures each jack (TRMT and RCV) to the front panel.
4	Remove the PC Board from the Control Panel. The two jacks, BUSY indicator, and switches are hardwired to the PC Board.
5	Install the new PC Board in the Control Panel so that the switches extend through the front panel.
6	Press the BUSY indicator in the grommet on the front panel and secure it with the retaining ring.
7	Secure the TRMT and RCV jacks to the front panel using one screw each.
8	Install the cover on the Control Panel so that the PC Board connectors mate properly with the cover socket and then secure it with four screws.

5.07 PARTS LIST

Table 5-4 lists the WILTRON part numbers for the replaceable assemblies used with the Return Loss measurement function.

Table 5-4. Parts List for Return Loss Measurement Function

<u>DESCRIPTION</u>	<u>WILTRON PART NO.</u>
Return Loss Control Panel	9310
PC Board, Controls	9310-ML-1008
Return Loss Measuring Module	9210
PC Board, Transmitter	9210-1
PC Board, Analog to Digital Converter	9210-2
PC Board, Receiver	9210-3
Return Loss Display Module	9471

5.08 FUNCTIONAL BLOCK DIAGRAM

Figure 5-7 is a functional block diagram for the Return Loss measurement function.

5.09 SIGNAL FLOW CHART

The Signal Flow Chart, Figure 5-8, can be used for troubleshooting the Return Loss measurement function, and may also be used when checking the cabling connections between the Control Panel, Equipment Shelf, and Display Housing.

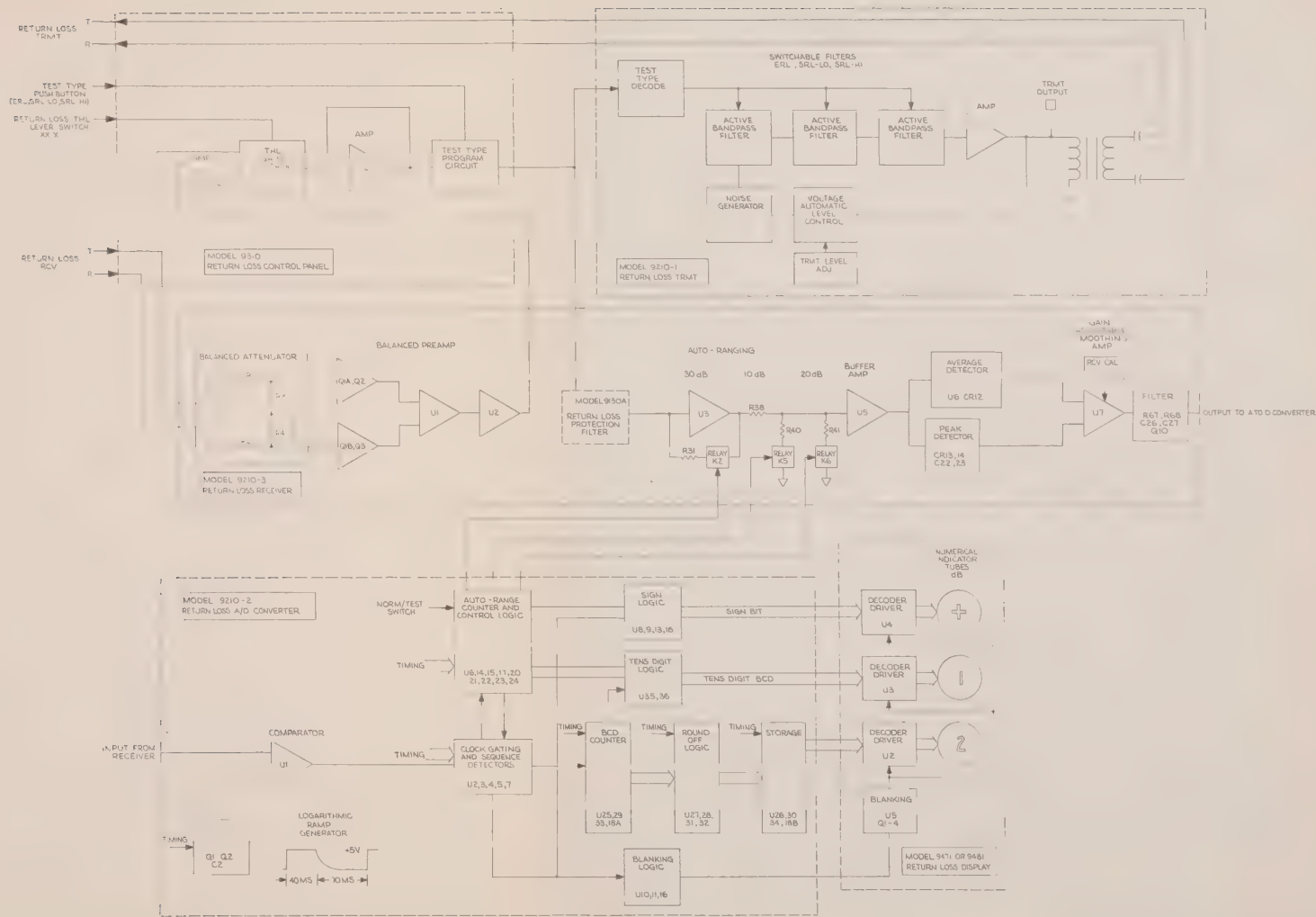


Figure 5-7. Return Loss Functional Block Diagram

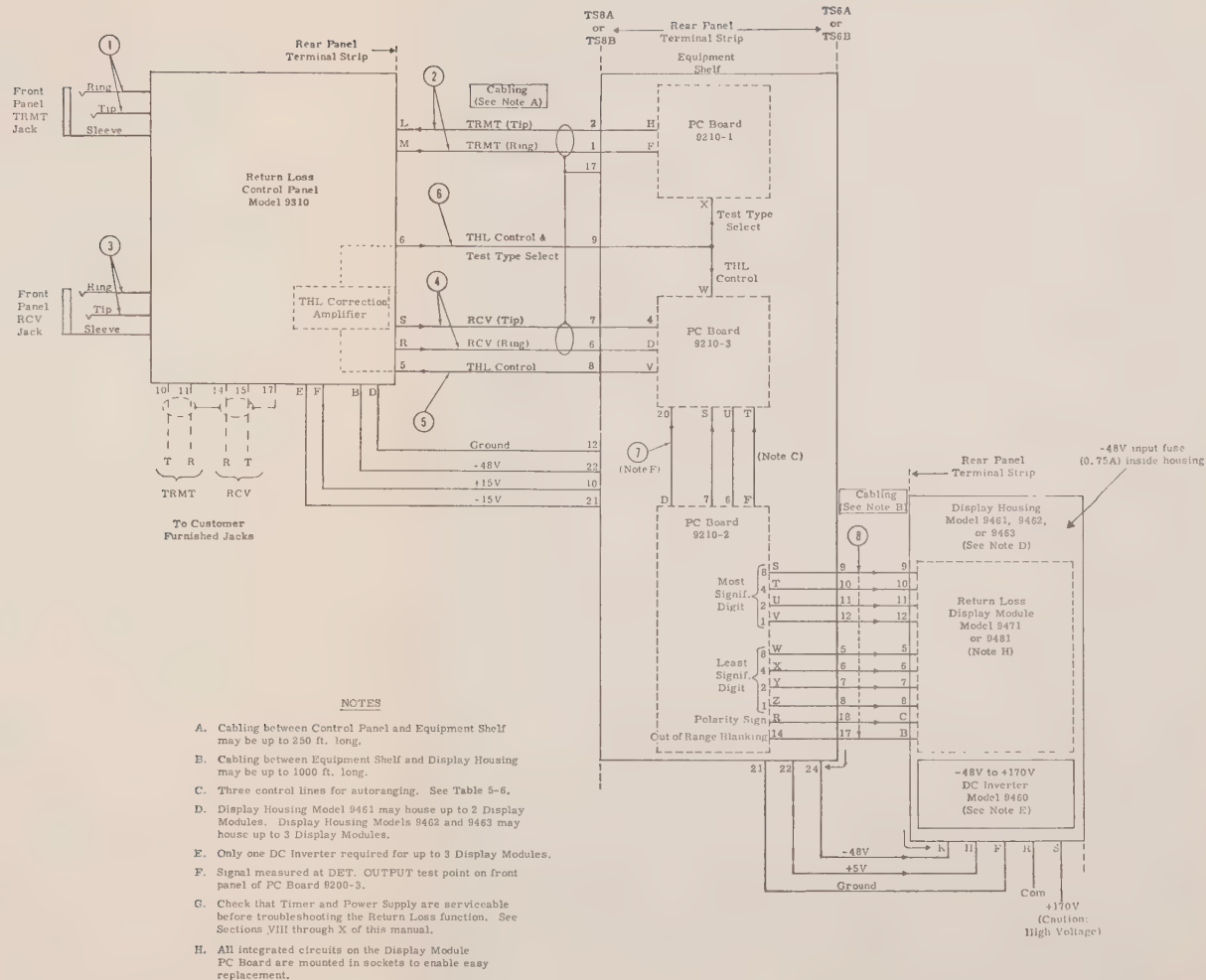


Figure 5-8. Return Loss
Signal Flow Chart,
Sheet 1 of 2

Table 5-5. BCD Logic Levels for Decimal Digits at Terminals on PC Board 9210-2 and Display Module.

ASSEMBLY TERMINAL STRIP	TERMINAL DESIGNATION OF BCD LINES				IDENTIFICATION
	8	1	2	1	
PC Board 9210-2	S	1	1	1	Most Significant Digit
	W	1	1	1	Least Significant Digit
	-	-	-	R	Polarity Sign
	-	-	-	1	Out of Range Blanking
Display Module	9	10	11	12	Most Significant Digit
	5	6	7	8	Least Significant Digit
	-	-	-	C	Polarity Sign
	-	-	-	R	Out of Range Blanking

BCD TO DECIMAL CONVERSION

BCD	8	4	2	1	DECIMAL
BCD Logic Levels	0	0	0	0	Decimal 0
	0	0	0	1	Decimal 1
	0	0	1	0	Decimal 2
	0	0	1	1	Decimal 3
	0	1	0	0	Decimal 4
	0	1	0	1	Decimal 5
	0	1	1	0	Decimal 6
	0	1	1	1	Decimal 7
	1	0	0	0	Decimal 8
	1	0	0	1	Decimal 9
	-	-	-	0	Out of Range
	-	-	-	1	In Range
	-	-	-	1	Out of Range (Digits Blanked)

Table 5-6. Return Loss Autoranging Control

AUTO-RANGE (dB)	CONTROL LINES							
	TERMINALS ON PC BOARD 9210-2				TERMINALS ON PC BOARD 9210-3			
	1	6	7	1	1	1	1	1
+40 to +52	0	0	0	0	0	0	0	0
+30 to +42	0	1	1	0	0	1	1	0
+20 to +32	0	1	0	0	0	1	0	0
+10 to +22	1	0	0	0	0	0	0	0
0 to +12	1	0	1	1	0	1	1	1
-10 to +2	1	1	0	1	1	0	1	0

1 = 3.5V dc approx.

0 = 0V dc approx.

HOW TO USE THE CHART

1. Use a VOM for the measurements.
2. Make the checks in the order shown below. If a particular voltage is abnormal, but the previous measurements are normal, it is likely that the PC Board between these two points is faulty.
3. If a spare PC Board of the same model is available, it can be substituted for the suspect board to see if the fault is cleared.

NOTE: On new installations, the cabling should be checked first for wiring errors.

TROUBLESHOOTING CHECKS

TEST POINT	READING	REMARKS
(1) (Note G)	+60 dBrn approx.	Control settings: FRL, 0 THz. Noise measuring set (e.g. WILTRON Level Noise Control Panel) connected to tip and ring through a 30 dB balanced attenuator.
(2)	Same as above.	Same as above.
(3)	+5 dBm (approx. 1.3V rms)	Control settings: FRL, 0 THz. Test signal of +5 dBm at 1004 Hz applied at RCV jack.
(4)	Same as above.	Same as above.
(5)	1.5V rms approx. to common (TS8-12)	Same as above.
(6)	a. Same as above. b. Test Type Selection 0V dc for ERI +5V dc for SRI, HI -5V dc for SRI, LO	Same as above.
(7)	3.3V dc approx. to common. See Note F.	Same as above.
(8)	See Table 5-5. Approx. reading is -7 dB return loss.	Same as above.

TERMINAL DESIGNATIONS

CONTROL PANELS AND DISPLAYS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	C	D	E	F	G	H	I	K	L	M	N	P	R

(Terminals G, I, O, and Q omitted)

EXTENDER BOARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
A	B	C	D	E	F	G	H	I	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z

(Terminals G, I, O, and Q omitted)

Figure 5-8. Return Loss Signal Flow Chart, Sheet 2 of 2

SECTION V(A)

2-WIRE RETURN LOSS MEASUREMENTS USING THE
MODEL 9311 RETURN LOSS CONTROL PANEL

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5A. GENERAL

5A.01 DESCRIPTION

The Model 9311 Return Loss Control Panel (see Figure 5A-1) is used with the Model 9310 Control Panel to enable 2-Wire Return Loss Measurements to be made. For 2-Wire measurements, the Model 9311 provides selection of 600 or 900 ohm impedance, hold coil in or out, and internal (600 or 900 ohm + 2.16 μ F) compromise network or external network. Selection of Test Type (ERL, SRL HI, SRL LO, or external oscillator) for 2-wire and 4-wire measurements is made on the Model 9310 Control Panel.

Access for 2-wire measurements is made at the SEND/RCV 2W jack on the Model 9311 Control Panel.

Some of the applications of 2-Wire Return Loss measurements are:

- Measure Through and Terminal Balance.
- Adjust Impedance Compensators.
- Adjust Negative Impedance and Hybrid Repeaters.
- Measure Structural Return Loss and Echo or Singing Return Loss of loaded cable pairs.

Specifications for the Model 9311 Return Loss Control Panel are as follows:

BALANCE OF INTERNAL HYBRID: ≥ 50 dB.

FREQUENCY RANGE OF INTERNAL
HYBRID: 200 Hz to 5 kHz.

INTERNAL NETWORK IMPEDANCE:
600 or 900 ohms $\pm 0.1\%$ in series with
a 2.16 μ F $\pm 1\%$ capacitor.

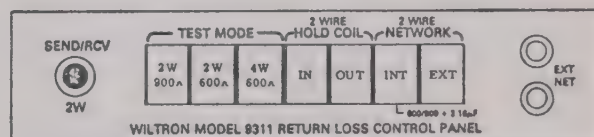


Figure 5A-1. Model 9311 Return Loss Control Panel

5A.02 OPERATING PROCEDURES

(A) Function of Controls and Connectors

Table 5A-1 describes the function of each control and connector on the Model 9311 Return Loss Control Panel.

Table 5A-1. Function of Controls and Connectors
on Model 9311 Return Loss Control Panel

CONTROL OR CONNECTOR	FUNCTION
<u>Test Mode Group</u>	
2W 900 Ω	Select for 2-wire, 900 ohm circuits.
2W 600 Ω	Select for 2-wire, 600 ohm circuits.
4W 600 Ω	Select for 4-wire, 600 ohm circuits.
<u>2-Wire Hold</u>	
IN	Switches hold coil in for circuit holding on 2-wire circuits.
OUT	Disconnects hold coil from the circuit under test.
<u>2-Wire Network</u>	
INT	Selects internal network, 600 or 900 ohms + 2.16 μ F.
EXT	Selects external network connected to EXT NET binding posts.
SEND/RCV 2W	Western Electric Type 310 jack used for 2-wire measurements.
EXT NET	Binding posts for connection of an external network, such as a Precision Balance Network (PBN).

(B) Terminal Balance, Echo Return Loss, and Singing Point Measurements, 2-Wire Operation

Table 5A-2 provides a step-by-step procedure for making 2-Wire Return Loss measurements. In this procedure, both the Model 9311 and 9310 Return Loss Control Panels are used. The Model 9315 Decade Capacitor Panel can be used for

the office DBO value if required, as shown in Figure 5A-2.

(C) 4-Wire Return Loss Measurements

Table 5A-3 is a procedure for 4-Wire Return Loss measurements using both the Model 9311 and 9310 Return Loss Control Panels.

Table 5A-2. Terminal Balance, Echo Return Loss, and Singing Point Measurements, 2-Wire Operation

STEP	PROCEDURE
	<u>NOTE</u> This is a procedure that can be used in 2-wire switching offices. The internal hybrid of the Model 9311 is used in place of the office test hybrid. Therefore, the measured values do not include the effects of the near end office test hybrid and associated drop equipment cabling. This measurement method should be used only if allowance is made for these effects. The readings obtained using this method should be compared with those of the 4-wire procedure described in Section II. If the results closely agree (within 1 dB), this procedure can be used to simplify office terminal balance.
1	Connect a capacitor ($\pm 1\%$) equal to the office NBO value to wirewrap pins 6 and 7 at the rear of the Model 9311 Control Panel. If a DBO capacitor is required, set the Model 9315 Decade Capacitor for the proper DBO value.
2	Press the RET LOSS pushbutton on the Model 9340 Test Selector Panel. Place a short or an open on the Model 9340 SEND/RCV 2W jack.
3	Press either the 2W 900 Ω or the 2W 600 Ω pushbutton on the Model 9311 Control Panel, to suit the impedance of the circuit under test. Press the INT pushbutton. Press the ERL pushbutton on the Model 9310 Control Panel.
4	Check that the Return Loss display is 0 dB. If not, adjust the ZERO CAL control at the rear of the Model 9311 Control Panel for a 0 dB reading. Remove the short or open and connect to the test jack of the circuit under test.
5	Press the 2-WIRE HOLD COIL IN pushbutton on the Model 9311 Control Panel.
6	Press the TALK DIAL pushbutton on the Model 9340 Test Selector Panel. Establish a connection through the reference outgoing trunk and switching equipment to a toll connecting trunk (see Figure 5A-2), then press the SEND RCV NORM pushbutton.
7	After the connection has been established, terminate the office side of the toll connecting trunk with a proper balance test termination (600/900 ohms, 2.16 μ F).
8	Press the ERL pushbutton on the Model 9310 Control Panel. Measure the Echo Return Loss (ERL), and note the reading.

Table 5A-2. Terminal Balance, Echo Return Loss, and Singing Point Measurements, 2-Wire Operation (Cont.)

STEP	PROCEDURE
9	Measure the Singing Return Loss High (SRL HI) and Singing Return Loss Low (SRL LO) by pressing the appropriate pushbutton on the Model 9310 Control Panel. Note the two readings. The lower of the two readings is considered to be the Singing Point of the circuit. <u>NOTE</u> An external oscillator can be connected to the Model 9310 Control Panel (as described in AW Sheet 3 of 7 of the DTMS Engineering Information Manual) if Structural Return Loss measurements are to be made.
10	To optimize the readings obtained in steps 9 and 10, refer to individual Plant Practices for Terminal Balance. <u>NOTE</u> Relative noise level can be checked by pressing the EXT OSC pushbutton on the Model 9310 Control Panel and noting the level (should be at least 10 dB below the return loss reading).

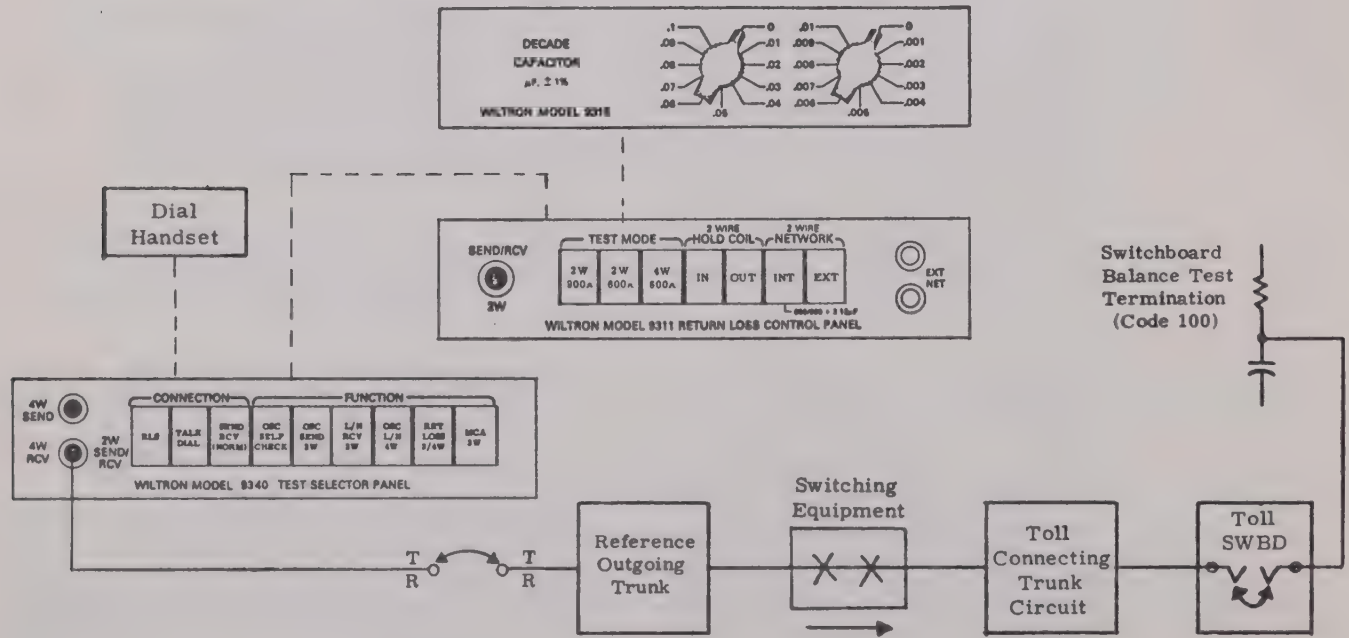


Figure 5A-2. Terminal Balance Typical Test Setup, 2-Wire Operation

Table 5A-3. 4-Wire Return Loss Measurements

STEP	PROCEDURE
	<u>4-Wire Measurements:</u>
1	Press the RET LOSS pushbutton on the Model 9340 Test Selector Panel. Patch the circuit under test to the 4W SEND and 4W RCV jacks.
2	Press the 4W 600 Ω pushbutton on the Model 9311 Return Loss Control Panel.
3	Make the 4-Wire Return Loss measurements using the Model 9310 Control Panel as described in Section V.

5A.03 PERFORMANCE VERIFICATION/ CALIBRATION

Table 5A-4 provides a performance verification/calibration procedure for the Model 9311 Return Loss Control Panel. No special test equipment is required for this procedure.

Table 5A-4. Performance Verification/Calibration Procedure

STEP	PROCEDURE
1	Ensure that the performance verification/calibration procedure for the Model 9310 Return Loss Control Panel given in Section V has been completed.
2	Press the ERL pushbutton on the Model 9310 Control Panel. Check that the THL CORRECTION dB switches and the TEST LEVEL POINT switch are set to zero. Check that the SEND RCV (NORM) pushbutton is pressed.
3	Press the 2W 600 Ω and INT pushbuttons on the Model 9311 Control Panel. Check that the 2 WIRE HOLD COIL IN pushbutton is pressed.
4	With the SEND/RCV 2W jack open, check that the Return Loss display reads 0 dB. If not, adjust the ZERO CAL control at the rear of the Model 9311 Control Panel.

5A.04 THEORY OF OPERATION

The function of the Model 9311 Control Panel for 2-Wire operation is similar to that for 4-Wire, except that the transmit and receive signals are applied through an internal precision hybrid. The circuit under test is checked against an internal compromise balance network (600 or 900 ohms in series with $2.16\mu\text{F}$). An external network such as a precision balance network (PBN) can be connected if desired for structural return loss measurements, etc.

5A.05 TROUBLESHOOTING

The 4-Wire Return Loss troubleshooting is provided in Section V. If the

system operates normally on 4-Wire Return Loss measurements, but not on 2-Wire measurements, it is likely that the Model 9311 Return Loss Control Panel is faulty.

5A.06 REMOVAL AND REPLACEMENT

Table 5A-5 provides instructions for removing and replacing the PC Board in the Model 9311 Return Loss Control Panel.

5A.07 REPLACEABLE PARTS

The PC Board inside the Model 9311 Return Loss Control Panel is replaceable. The WILTRON part number for the PC Board is 9311-ML-4809-3.

Table 5A-5. PC Board Removal and Replacement

STEP	PROCEDURE
1	Remove the four screws from the cover of the Return Loss Control Panel. Remove the cover by pulling it straight back to detach the cover from the PC Board connector inside the Control Panel.
2	Unsolder the leads to the external network banana jacks.
3	Remove the screw that secures the jack to the front panel.
4	Remove the PC Board from the Control Panel. The jack is hardwired to the PC Board.
5	Install the new PC Board in the Control Panel so that the switches extend through the front panel.
6	Connect and solder the wires to the external banana jacks, with the white wire at the top jack.
7	Secure the jack to the front panel using one screw.
8	Install the cover on the Control Panel so that the PC Board connectors mate properly with the cover socket and then secure it with four screws.

SECTION VII

MULTIMETER CABLE ANALYZER

SECTION VII	CONTENTS	PAGE	SECTION VII	CONTENTS	PAGE
7.	GENERAL	7-1	(A) Introduction	7-28	
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	FUNCTION.....	7-1	(C) Calibration	7-31	
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	(A) Function of Controls,		7.05	TROUBLESHOOTING	7-33
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	(C) Multimeter Cable Analyzer		7.08	FUNCTIONAL BLOCK	
	Measurements	7-5		DIAGRAM.....	7-34
	AC Voltage Measurements ..	7-6	7.09	SIGNAL FLOW CHART....	7-39/7-40
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	Resistance Measurements ..	7-10	7.	GENERAL	
	Capacitance Measurements ..	7-12			
	Direct Current Measure-		7.01	DESCRIPTION OF FUNCTION	
	ments	7-14		The Multimeter Cable Analyzer	
	Measurement Applications			(MCA) measures ac and dc volts, dc	
	of the MCA	7-17		milliamperes, resistance in kilohms or	
	Test Jack Arrangements			megohms, and capacitance in microfarads.	
	for Loop Current	7-17		As shown in Figure 7-1, the Control Panel	
	AC Pickup (Induction)	7-18		provides pushbutton selection of the six	
	Ringing Voltage	7-18		measurement functions and also the type	
	Battery Voltage	7-18		of connection (Tip to Ring, Tip to Ground,	
	Foreign Battery Voltage ..	7-18		or Ring to Ground) to the circuit under	
	Loop Resistance.....	7-19		test. Access to the Multimeter Cable Ana-	
	Crossed or Grounded			lyzer measurement functions is provided	
	Pairs	7-19		by the front panel INPUT jack or a cus-	
	Short Circuit Check.....	7-19		tommer-supplied jack connected to wire	
	Leakage Resistance.....	7-20		wrap terminals at the rear of the panel.	
	Cable Capacitance	7-21		The Multimeter Cable Analyzer Display	
	Capacitive Balance	7-21		Module provides polarity indication for	
	Number of Ringers on			the dc voltage and current functions. The	
	a Cable Pair	7-22		Display Module can be installed in a	
	Presence of Bridged Taps			Display Housing with a Level/Noise, Fre-	
	on a Cable Pair	7-22		quency, or Return Loss Display if desired.	
	Measuring Distance to a			The Multimeter Cable Analyzer Measuring	
	Break	7-23		Module consists of two PC boards (Models	
	Distance to Fault on a			9270-1 and 9270-2) installed in the Equip-	
	Cable Pair	7-25		ment Shelf in addition to the Timer Module.	
7.03	PERFORMANCE VERIFI-			Specifications for the Multimeter Cable	
	CATION/CALIBRATION	7-28		Analyzer measuring functions are pro-	
				vided in Table 7-1 following.	

Table 7-1. Specifications for Multimeter Cable Analyzer
Measurement Functions

DC Volts:

<u>Rated Range:</u>	0-300V in 2 ranges, (0-99.9V, 90-300V, autoranging).	
<u>Accuracy:</u>	<u>Range</u>	
	0-99.9V	0.15% of reading + 1 digit
	90-300V	0.35% of reading + 1 digit
<u>Overload Capability:</u>	Meets or exceeds requirements of PUB 41009 (see note).	
<u>DC Input Resistance:</u>	1 Megohm.	
<u>Polarity:</u>	Instantaneous automatic selection and display.	

AC Volts

<u>Rated Range:</u>	0-300V rms in 2 ranges, (0-99.9V, 90-300V, autoranging).	
<u>Accuracy:</u>	<u>Range</u>	
	50 Hz to 20 kHz	±0.8% of reading + 1 digit
	20 Hz to 50 kHz	±3.0% of reading + 1 digit
<u>Overload Capability:</u>	Meets or exceeds requirements of PUB 41009 (see note).	
<u>Input Impedance:</u>	1 Megohm shunted by the 150pF plus the wiring capacitance between the WILTRON Control Panel and Equipment Shelf (typically 20pF per foot).	
<u>Detection:</u>	Full wave averaging detector; instrument calibrated to read the rms value of a sine wave.	

DC Current

<u>Rated Range:</u>	0-200mA in 2 ranges, (0-99.9mA, 90-200mA autoranging).	
<u>Accuracy:</u>	<u>Range</u>	
	0-99.9mA	0.25% of reading + 1 digit
	90-200mA	0.45% of reading + 1 digit
<u>Overload Capability:</u>	Accepts up to ±1A before circuit breaker responds. Instrument will not be damaged by a direct connection to the office 48V battery.	
<u>Burden Voltage:</u>	2mV/mA input current.	
<u>Polarity:</u>	Instantaneous automatic selection and display.	

Table 7-1. Specifications for Multimeter Cable Analyzer
Measurement Functions (Cont.)

<u>Resistance</u>			
<u>Rated Range:</u>		0-9.99M Ω in 5 ranges, (0-.999, .90-9.99, 9.0-99.9k Ω , 0-.999M Ω , .9-9.99M Ω autoranging).	
<u>Accuracy:</u>		<u>Test Current Applied to Measured Resistance</u>	
k Ω Position	<u>Range</u> 0-.999k	0.2% of reading + 1 digit	1mA
	.9-9.99k	0.35% of reading + 1 digit	1mA
	9-99.9k	0.5% of reading + 1 digit	1mA
M Ω Position	0-.999M	0.5% of reading + 1 digit	100 μ A
	.9-9.99M	1% of reading + 1 digit	10 μ A
<u>Overload Capability:</u>		Protected from 300V dc across inputs, either polarity.	
<u>Configuration:</u>		Constant current, two-terminal measurement. Up to 160V may appear across the resistance being measured.	
<u>Capacitance:</u>			
<u>Range:</u>		0-9.99 μ F in 2 ranges, (0-.999 μ F, .90-9.99 μ F, autoranging).	
<u>Accuracy:</u>			
	<u>Range</u> 0-2.99 μ F	0.2% of reading + 1 digit	
	2.99-9.99 μ F	see specification for series resistance and inductance	
<u>Overload Capability:</u>		As per PUB 41009 (see note).	
<u>Max. External Series Resistance:</u>			
	Up to 15k Ω from 0 to .999 μ F measured capacitance for specified accuracy.		
	Up to 3k Ω from 0 to 2.99 μ F measured capacitance for specified accuracy.		
	Up to 2k Ω from 0 to 9.99 μ F measured capacitance for 1% accuracy or better.		

Table 7-1. Specifications for Multimeter Cable Analyzer
Measurement Functions (Cont.)

Max. External Series

Inductance:

Up to 35 Henries inductance from 0 to $9.99\mu\text{F}$ measured capacitance for 1% accuracy or better.

Measurements in the presence of up to 30V rms power line pickup can be made. Accurate measurements are made in spite of series loop resistance and inductance (e. g. load and ringer coils, etc.) as stated above.

General Specifications

Autoranging:

Provided in all measurements. All readings are updated every 0.5 seconds (see response time discussion). Measurements can be made with up to 30 volts rms of pickup interference from line power.

Response Time
of Display

A two-position switch on the Measuring Module selects either "Normal" autoranging time or a "Faster Response" position. The latter switch position holds the function in its top range, e. g. 0 to 299V for DC or AC volts.

<u>MEASUREMENT FUNCTION</u>	<u>RESPONSE TIME, NORMAL POSITION</u>	<u>FASTER RESPONSE POSITION (Max. Time)</u>
AC Volts	2 sec. max.	1 sec.
DC Volts	2 sec. max.	1 sec.
DC Current	2 sec. max.	1 sec.
Resistance		
a. Kilohms	2.5 sec. max.	1 sec.
b. Megohms	2 sec. *	1 sec. *
Capacitance	2 sec. max.	1 sec.

*Depends on the time constant of the circuit on test; e. g., if the leakage resistance being measured is 5 megohms but has $1\mu\text{F}$ shunt capacitance, the response time will be greater than 5 seconds. It will be apparent to the craftsman within the normal 2 sec. period that acceptable or unacceptable readings are being obtained.

NOTE

Protected from 350 volt peak (ac + dc) longitudinal voltage. Withstands a simulated lightning strike across the input terminals or from either terminal to ground. Meets or exceeds requirements of Reference PUB 41009, established by Bell Labs.

7.02 OPERATING PROCEDURES

(A) Function of Controls, Indicators, and Connectors

Table 7-2 describes the function of the controls, indicators, and connectors on the Multimeter Cable Analyzer Control Panel.

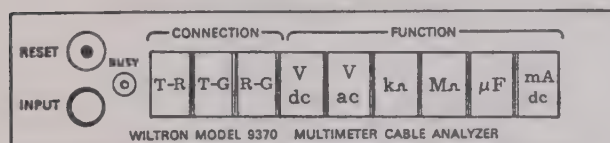


Figure 7-1. Multimeter Cable Analyzer Control Panel Model 9370

Table 7-2. Function of Controls, Indicators, and Connectors

BUSY: Light-emitting diode indicator lamp. When indicator is not lit, the Multimeter Cable Analyzer functions are available for use. The indicator is lit only when the Multimeter Cable Analyzer measurement equipment is being used by another test location (e.g. ITMS shared-access systems).

INPUT: Western Electric Type 310 jack (connected Tip and Ring). When a plug is inserted in the jack, the Multimeter Cable Analyzer functions are available if the BUSY indicator is not lit.

NOTE

The sleeve connection is brought out on terminal N at the rear of the Control Panel. If sleeve holding is needed, connect the holding circuit to this terminal.

RESET: An overload current circuit breaker for the mA dc function. The circuit breaker trips when more than 1A flows into the Control Panel INPUT jack. Before resetting the pushbutton, the circuit on test must be disconnected and the overload removed.

CONNECTION: Three back-lighted pushbutton switches. Provides selection of Multimeter Cable Analyzer to test cable connections of either Tip to Ring, Tip to Ground, or Ring to Ground.

FUNCTION: Bank of six back-lighted pushbutton switches. Provides selection of one of the following measurement functions:

Voltage: 0 to 300V ac rms
0 to ± 300 V dc

Direct Current: 0 to ± 200 mA

Resistance: 0 to 99.9k ohms
0 to 9.99M ohms

Capacitance: 0 to 9.99 μ F

k Ω ZERO ADJ.: At rear of panel (shown in Figure 7-2). Used to zero out the effects of wiring resistance from the Control Panel to the Equipment Shelf. Adjustment is made with the k Ω pushbutton selected.

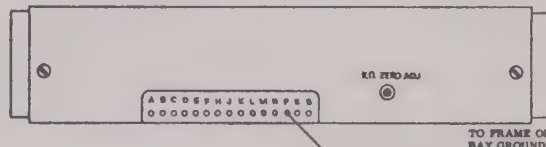


Figure 7-2. Multimeter Cable Analyzer Control Panel, Rear View

(B) Operational Checks

The Operational Check procedures on pages 7-26 through 7-28 can be used to verify that the Multimeter Cable Analyzer measurement functions are in working condition.

(C) Multimeter Cable Analyzer Measurements

Pages 7-6 through 7-15 provide operating procedures for each measurement function. Figures 7-8 through 7-22 on pages 7-17 through 7-24 show typical applications of the Multimeter Cable Analyzer.

AC VOLTAGE MEASUREMENTS

USE TO MEASURE:

- a. Ac pickup due to power line induction.
- b. Ringing voltages (see DISPLAY RESPONSE TIME below).
- c. Balance of cable pairs. This is done by comparing the Tip to Ring voltage with the Tip to Ground and Ring to Ground voltages and noting the difference.
- d. Ac voltages over a frequency range of 20 Hz to 50 kHz.

TEST CONNECTIONS: Tip to Ring, Tip to Ground, or Ring to Ground as desired (see Figure 7-3 below).

CONDITIONS: Measurements are not affected by battery voltage on the circuit under test.

DISPLAY RESPONSE TIME: When measuring a ringing voltage with a very short ring cycle (less than 2 seconds on ring), the measuring circuits may be arranged to have a faster response time. This is done by setting the switch on the front panel of PC Board 9270-1 (in the Equipment Shelf) to FASTER RESPONSE.

OPERATION: Follow procedure on page 7-7. See Figures 7-9 and 7-10 for typical applications.

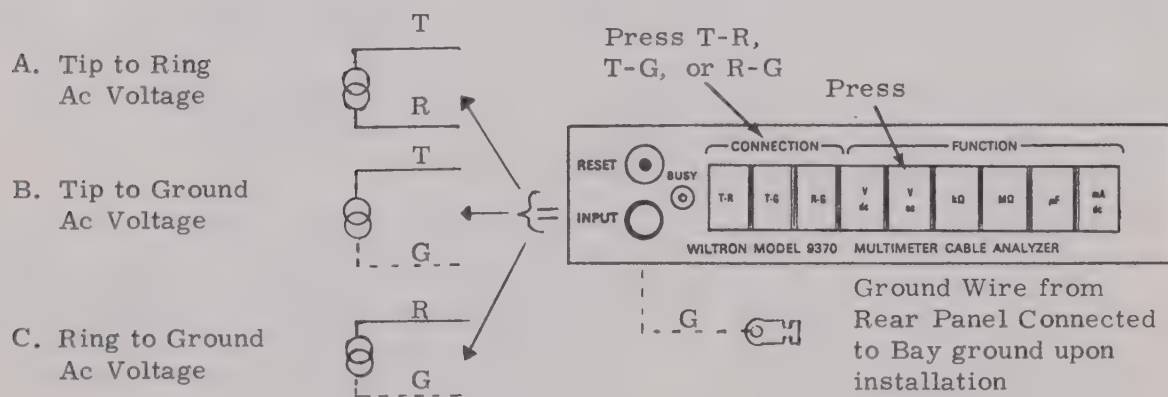


Figure 7-3. Ac Voltage Measurements, Test Connections

AC VOLTAGE MEASUREMENTS

STEP	PROCEDURE
1	Determine the type of test connections required for the measurement to be made (Tip to Ring, Tip to Ground, or Ring to Ground). Press the appropriate CONNECTION pushbutton and the Vac pushbutton on the Multimeter Cable Analyzer Control Panel.
2	Patch the circuit or device under test to the INPUT jack on the Multimeter Cable Analyzer Control Panel (see Figure 7-3). If the BUSY indicator is lit, wait until the light goes out before making the measurement.
	<u>NOTE</u> When the BUSY indicator is lit, the Multimeter Cable Analyzer measurement function is being used at another test location.
3	Note the readout on the Multimeter Cable Analyzer Panel Display (or Close View or Distant View Display Housing).

DC VOLTAGE MEASUREMENTS

USE TO MEASURE: a. Battery voltage.
b. Foreign voltages.

TEST CONNECTIONS: Measure Tip to Ring, Tip to Ground, or Ring to Ground, as desired. (See Figure 7-4 below.)

CONDITIONS: Measurements are not affected by up to 30V rms power line pickup even when Tip to Ground or Ring to Ground measurements are being made.

OPERATION: See page 7-9 for procedure. See Figures 7-11 and 7-12 for typical applications.

POLARITY INDICATION: To obtain the correct polarity indication on the Display Module, connect the battery common lead (usually the positive one) to the RING connection of the INPUT jack for Tip to Ring measurements. Tip to Ground and Ring to Ground polarity indication is always correct, since the measurement is made relative to ground (which is where the battery common lead is usually connected).

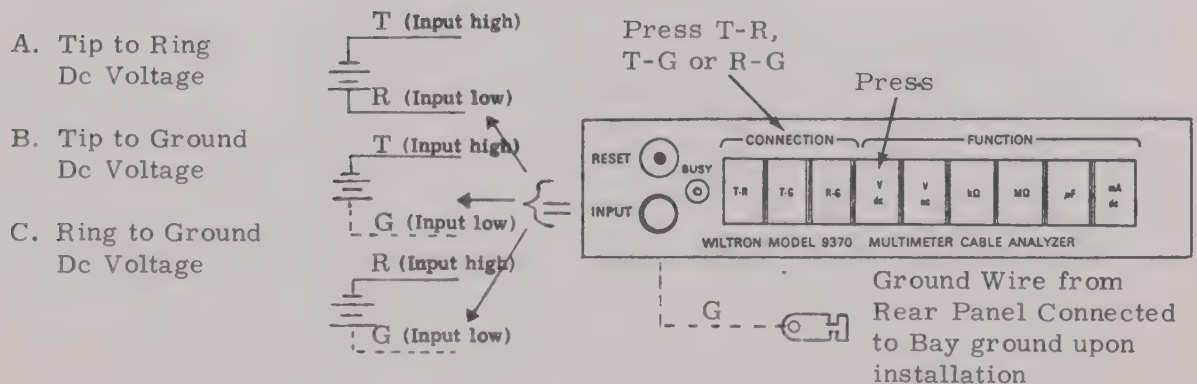


Figure 7-4. Dc Voltage Measurements, Test Connections

DC VOLTAGE MEASUREMENTS

STEP	PROCEDURE
1	Determine the type of test connections required for the measurement to be made (Tip to Ring, Tip to Ground, or Ring to Ground). Press the appropriate CONNECTION pushbutton and the Vdc pushbutton on the Multimeter Cable Analyzer Control Panel.
2	Patch the circuit or device under test to the INPUT jack on the Multimeter Cable Analyzer Control Panel (see Figure 7-4). If the BUSY indicator is lit, wait until the light goes out before making the measurement.
	<u>NOTE</u> When the BUSY indicator is lit, the Multimeter Cable Analyzer measurement function is being used at another test location.
3	Note the readout on the Multimeter Cable Analyzer Panel Display (or Close View or Distant View Display Housing).
4	The correct polarity of the measured voltage is automatically displayed when the Ring (for Tip to Ring connections) or the Ground (for Tip to Ground or Ring to Ground connections) of the INPUT jack is connected to the common battery return of the circuit being measured (normally ground, since battery positive is grounded).

RESISTANCE MEASUREMENTS

USE TO MEASURE:

- a. Loop resistance (on $k\Omega$ range).
- b. Crossed pairs (on $k\Omega$ range).
- c. Metallic short circuits (on $k\Omega$ range).
- d. Leakage resistance (on $M\Omega$ range).

TEST CONNECTIONS: Tip to Ring, Tip to Ground, or Ring to Ground, as desired.
(See Figure 7-5 below.)

CONDITIONS:

- a. No dc voltage (e.g. battery or foreign voltage) can be present on the circuit under test between Tip and Ring, Tip and Ground, or Ring and Ground. Otherwise inaccurate readings will be obtained.
- b. Measurements are not affected by up to 30V rms power line pickup even when Tip to Ground or Ring to Ground resistance measurements are being made.

OPERATION: See page 7-11 for procedure. See Figures 7-13 through 7-16 for typical applications.

CAUTION

TO OBTAIN DYNAMIC LEAKAGE RESISTANCE MEASUREMENTS THAT CORRELATE WITH EXISTING TEST METHODS AND WORKING VOLTAGES, THE CABLE PAIR OR CIRCUIT ON TEST CAN BECOME CHARGED WITH UP TO 160 VOLTS DC.

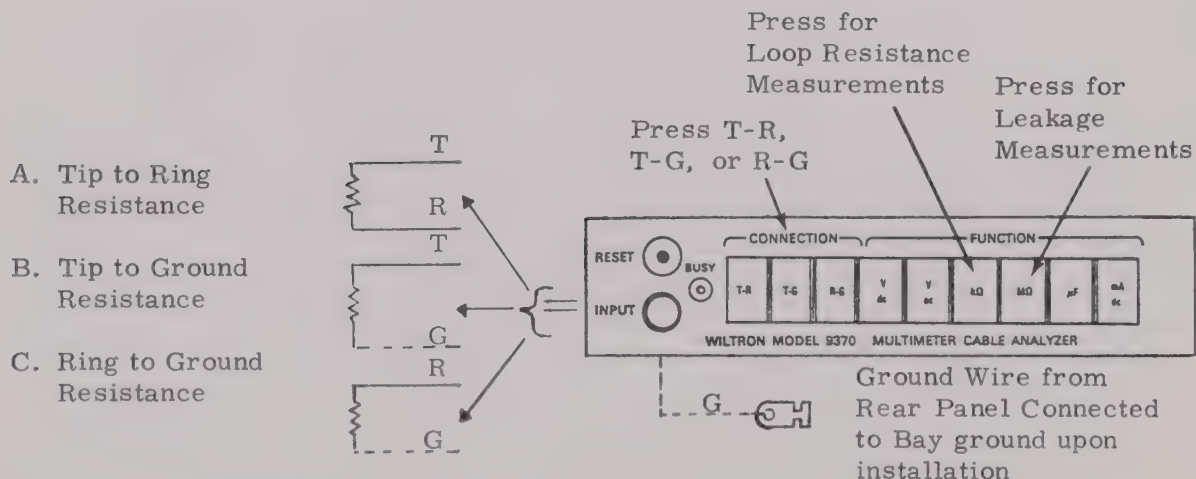


Figure 7-5. Resistance Measurements

RESISTANCE MEASUREMENTS

STEP	PROCEDURE
1	Determine the type of test connections required for the measurement to be made (Tip to Ring, Tip to Ground, or Ring to Ground). Press the appropriate CONNECTION pushbutton and the Vdc pushbutton on the Multimeter Cable Analyzer Control Panel.
2	Patch the circuit or device under test to the INPUT jack on the Multimeter Cable Analyzer Control Panel (see Figure 7-5). If the BUSY indicator is lit, wait until the light goes out before making the measurement.
	<u>NOTE</u> When the BUSY indicator is lit, the Multimeter Cable Analyzer measurement function is being used at another test location.
3	Check for the presence of any dc voltage, such as battery or foreign voltage, from Tip to Ring, Tip to Ground, or Ring to Ground. If any dc voltage is present, DO NOT make the resistance measurement.
4	Press the desired CONNECTION pushbutton. Press the kΩ pushbutton for loop resistance checks, or the MΩ pushbutton for leakage resistance checks, and note the readout on the Multimeter Cable Analyzer Panel Display (or Close View or Distant View Display Housing). For kΩ values higher than 99.9kΩ, or MΩ values higher than 9.99MΩ, the display digits are blanked and the + sign is lit to indicate an overrange condition.
	<u>NOTE</u> The kΩ ZERO ADJ control at the rear of the Control Panel must be adjusted on initial installation, and when it is desired to zero out the external resistance to an access shoe. This is done by applying a short at the INPUT jack with proper connections for the CONNECTION pushbutton selected, then selecting the kΩ pushbutton and adjusting the control for a .000kΩ display.
5	After the resistance measurement has been made, press the mA dc pushbutton to discharge the cable pair or circuit of the test voltage.

CAPACITANCE MEASUREMENTS

USE TO MEASURE:

- a. Cable pair capacitance (see Figure 7-17).
- b. Cable length (see Figure 7-17).
- c. Capacitive balance to find split cable pairs (see Figure 7-18).
- d. Distance to a break (open) in a cable pair (see Figure 7-21).
- e. DBO and NBO capacitor values.
- f. Number of ringers on a cable pair (see Figure 7-19).
- g. Cable pair capacitance for presence of bridged taps (see Figure 7-20).

TEST CONNECTIONS: Tip to Ring, Tip to Ground, or Ring to Ground (see Figure 7-6 below).

CONDITIONS:

- a. No dc voltage (battery or foreign voltage) can be present on the cable pair under test between Tip and Ring, Tip and Ground, or Ring and Ground. Otherwise inaccurate readings will be obtained.
- b. Measurements are not affected by up to 30V rms power line pickup even when Tip to Ground or Ring to Ground capacitance measurements are being made.

OPERATION: See page 7-13 for procedure.

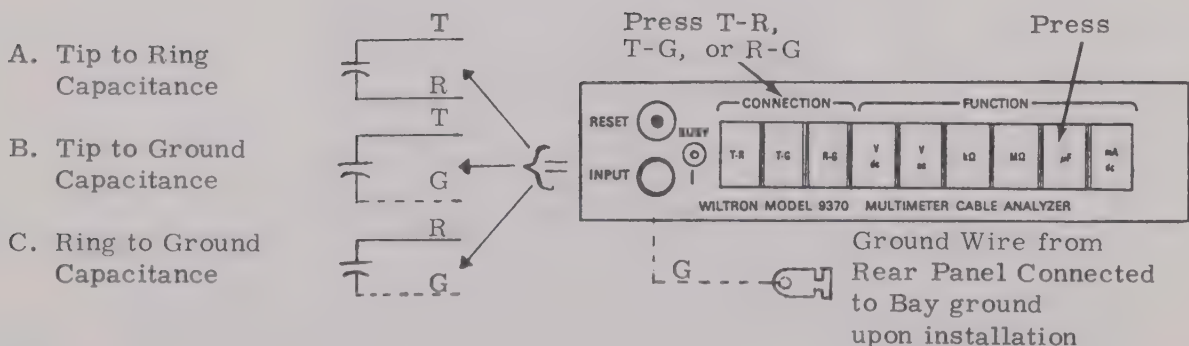


Figure 7-6. Capacitance Measurements

CAPACITANCE MEASUREMENTS

STEP	PROCEDURE
1	Determine the type of test connections required for the measurement to be made (Tip to Ring, Tip to Ground, or Ring to Ground). Press the appropriate CONNECTION pushbutton and the Vdc pushbutton on the Multimeter Cable Analyzer Control Panel.
2	Patch the circuit or device under test to the INPUT jack on the Multimeter Cable Analyzer Control Panel (see Figure 7-6). If the BUSY indicator is lit, wait until the light goes out before making the measurement.
	<u>NOTE</u> When the BUSY indicator is lit, the Multimeter Cable Analyzer measurement function is being used at another test location.
3	Check that the battery or a foreign voltage is not present. If any dc voltage is present, DO NOT make a capacitance measurement.
4	If no dc voltage is present, press the mA dc pushbutton. This ensures that the capacitance of the circuit under test is discharged of any dc charge (through the 1-ohm shunt resistor in the Control Panel) before making the measurement.
5	Press the μF pushbutton and note the readout on the Multimeter Cable Analyzer Panel Display (or Close View or Distant View Display Housing).
6	Refer to Figure 7-23 and Table 7-3 for conversion of capacitance reading to cable length (also used for cable fault location).

DIRECT CURRENT MEASUREMENTS

USE TO MEASURE: a. Loop current in telephone and telegraph circuits (see Figure 7-8).
b. Pull-in current of relays.

TEST CONNECTIONS: Tip to Ring (Tip to Ground or Ring to Ground are not usually used for current measurements) (see Figure 7-7 below).

NOTE

If your current loop jack has a shunt resistor (usually 10 ohms) wired to it, the resistor should be disconnected or another jack (without a resistor) wired in series with the existing jack. Otherwise the resistor will cause inaccurate readings.

CONDITIONS: a. Instrument is protected by a circuit breaker for input currents greater than 1 amp.
b. A direct connection to the 48V office battery will not damage the instrument.

OPERATION: See page 7-15 for procedure.

POLARITY INDICATION: The correct polarity of the measured current is automatically displayed when the Ring of the INPUT jack is connected to the common or return of the circuit being measured (see Fig. 7-8).

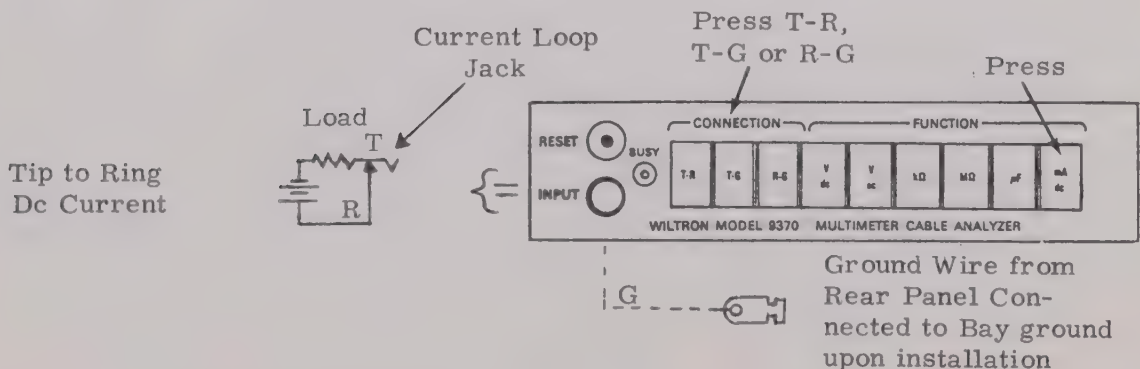
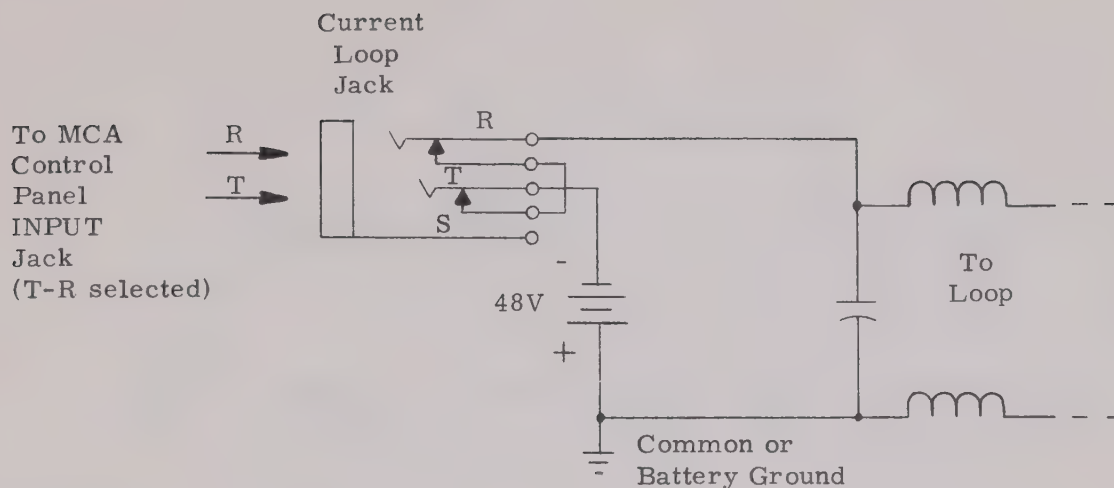


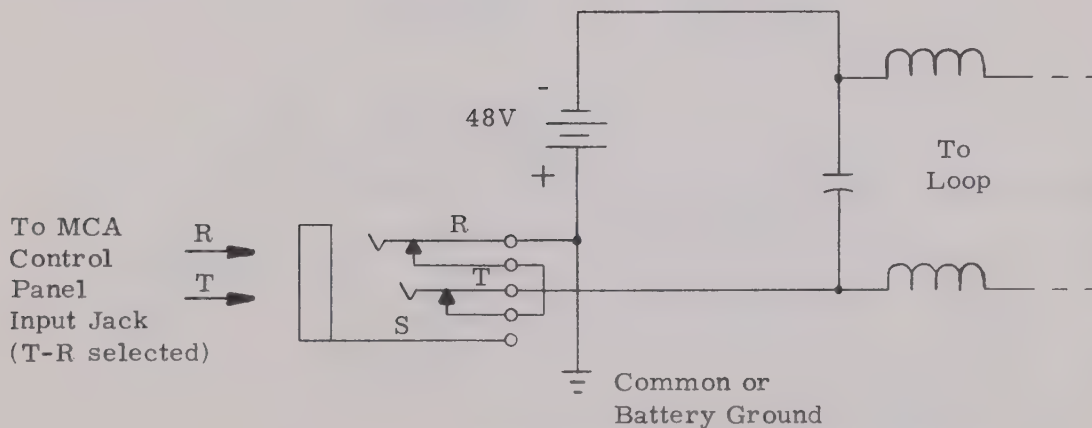
Figure 7-7. Direct Current Measurements

DIRECT CURRENT MEASUREMENTS

STEP	PROCEDURE
1	Press the T-R CONNECTION pushbutton on the Multimeter Cable Analyzer Control Panel.
2	Patch the circuit or device under test to the INPUT jack on the Multimeter Cable Analyzer Control Panel (see Figures 7-7 and 7-8). If the BUSY indicator is lit, wait until the light goes out before making the measurement. <u>NOTE</u> When the BUSY indicator is lit, the Multimeter Cable Analyzer measurement function is being used at another test location.
3	Press the mA pushbutton and note the readout on the Multimeter Cable Analyzer Panel Display (or Close View or Distant View Display Housing). <u>NOTE</u> If more than 1 amp of current is applied to the INPUT jack, the RESET button will pop out. Disconnect the patch cord from the INPUT jack and check all test connections. The source of excess current must be removed before pressing the RESET button.



A. DC Loop Current Measurement with Loop Current Jack in Battery Side of Loop



B. DC Loop Current Measurement with Loop Current Jack in Common or Battery Ground Side of Loop

Figure 7-8. Test Jack Arrangements for Loop Current Measurements

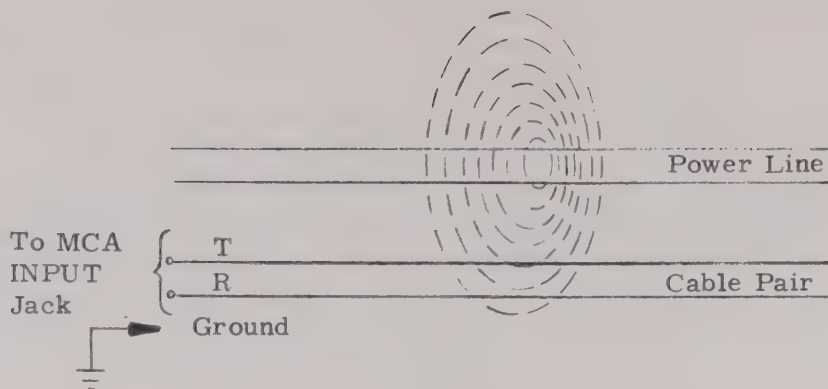


Figure 7-9. Measurement of AC Pickup (Induction)

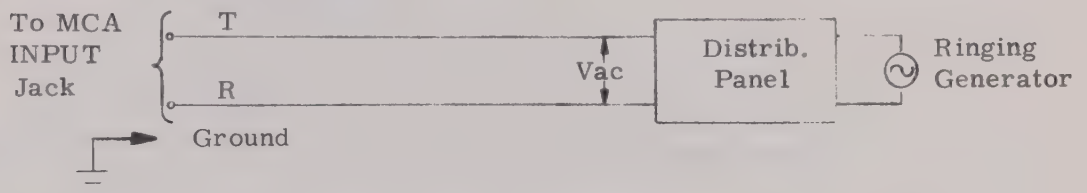


Figure 7-10. Ringing Voltage Measurement

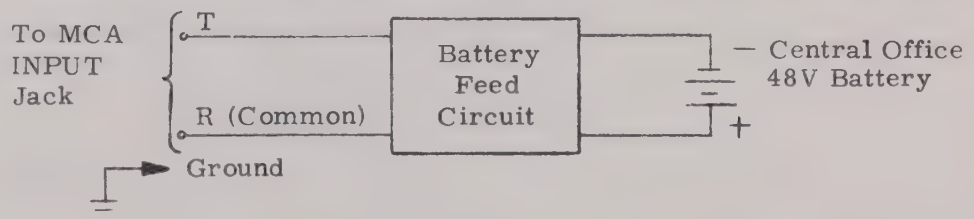


Figure 7-11. Battery Voltage Measurement

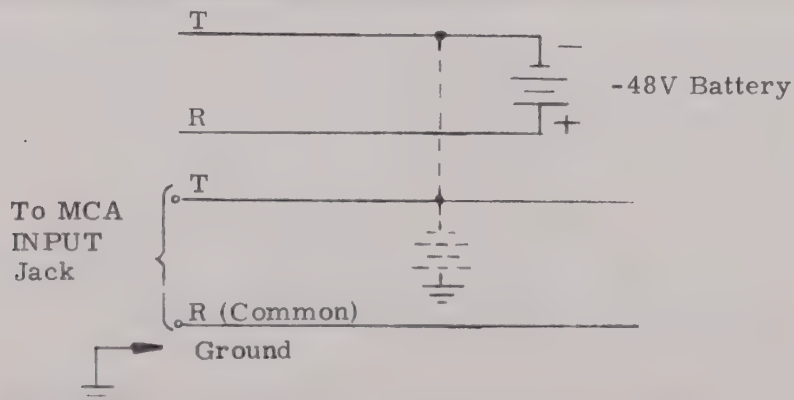


Figure 7-12. Check for Foreign Battery Voltage

$$R_{\text{Total}} = R1 + R2$$

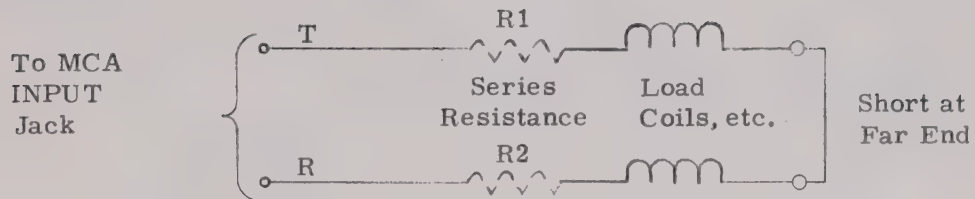


Figure 7-13. Loop Resistance Measurement

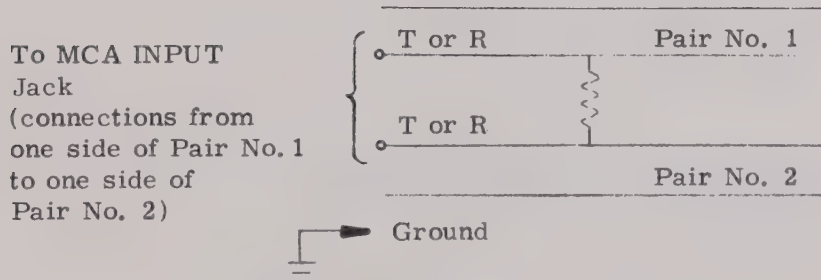


Figure 7-14. Check for Crossed or Grounded Pairs

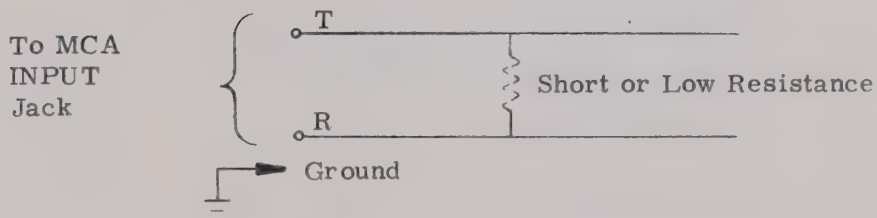
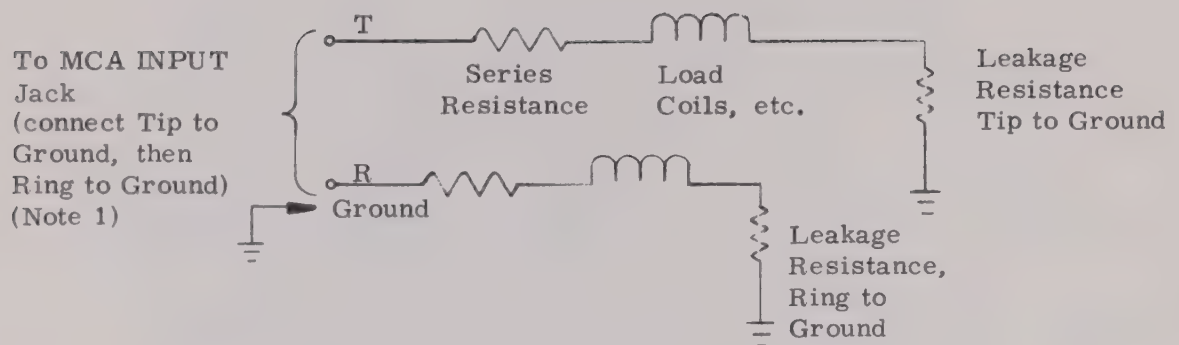


Figure 7-15. Short Circuit Measurement



NOTE 1

Measure from Tip to Ground (T-G pushbutton), then from Ring to Ground (R-G pushbutton).

NOTE 2

Leakage resistance measurements are made with a low-current 160V dc test voltage to ensure test conditions are the same as that obtained with existing test board ohmmeters.

Figure 7-16. Leakage Resistance Measurements

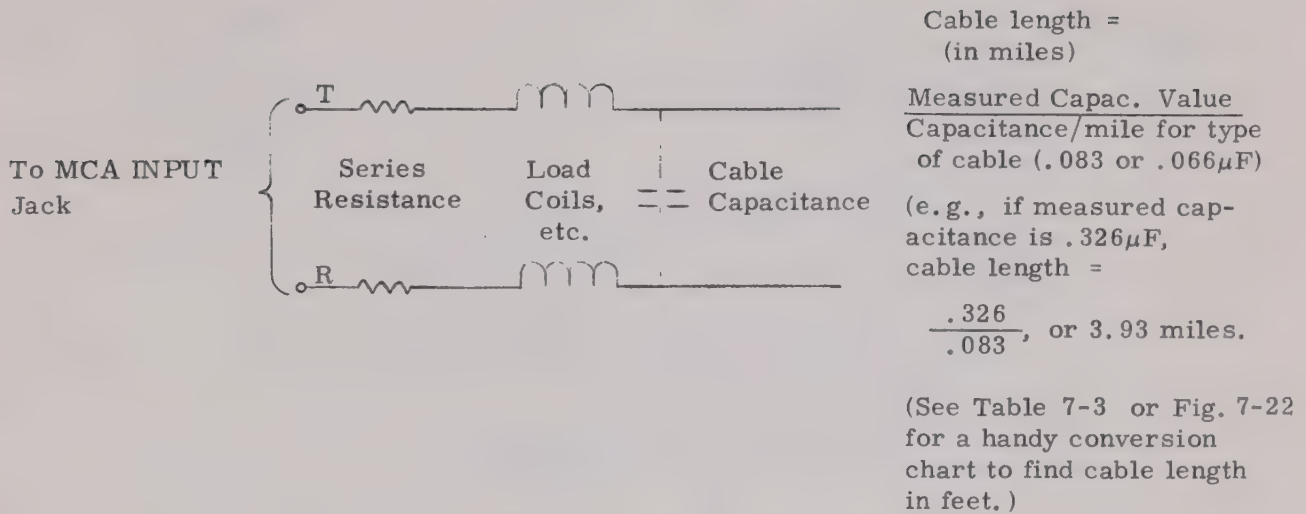


Figure 7-17. Cable Capacitance Measurement

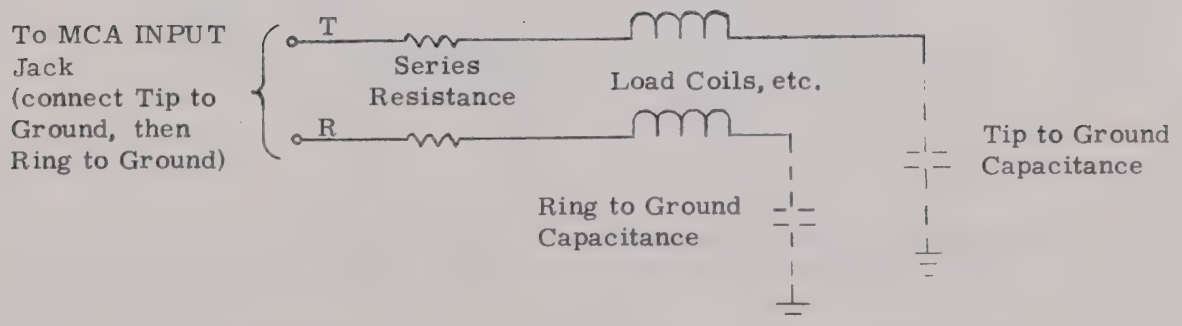


Figure 7-18. Capacitive Balance Measurement

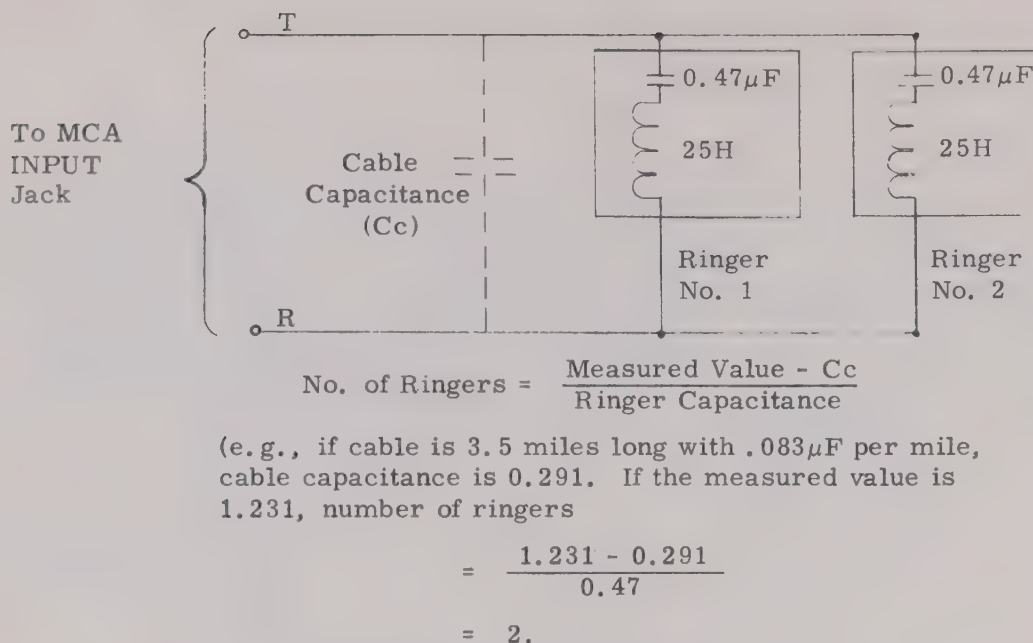
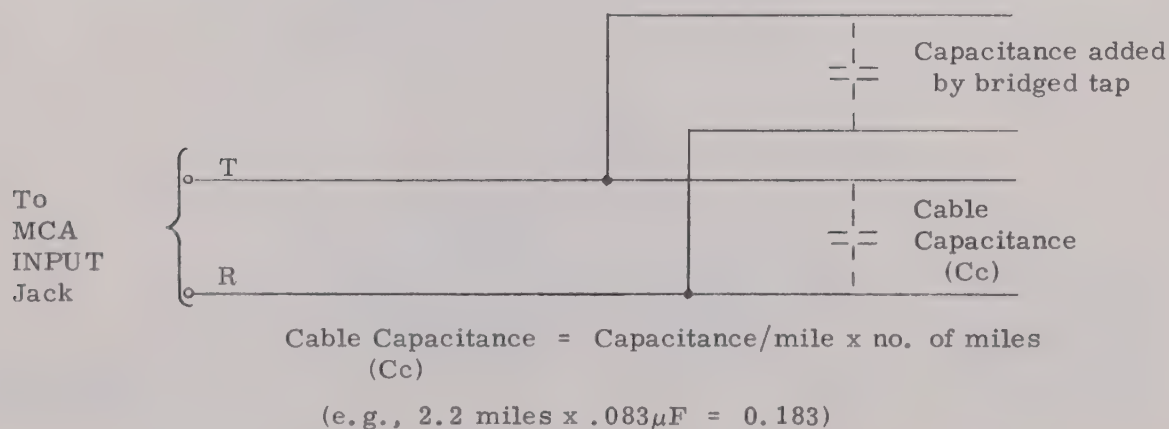


Figure 7-19. Checking Number of Ringers on a Cable Pair (when connected Tip and Ring).



Capacitance added by bridged tap = Measured Capacitance - Cable Capacitance
 (e.g., measured capacitance of 0.225 μ F - 0.183 C_c = 0.042 μ F added by bridged tap)

This means that approx. 2672 feet of cable was added by the bridged tap (if the cable is .083 μ F/mile).

Figure 7-20. Checking for Presence of Bridged Taps on a Cable Pair

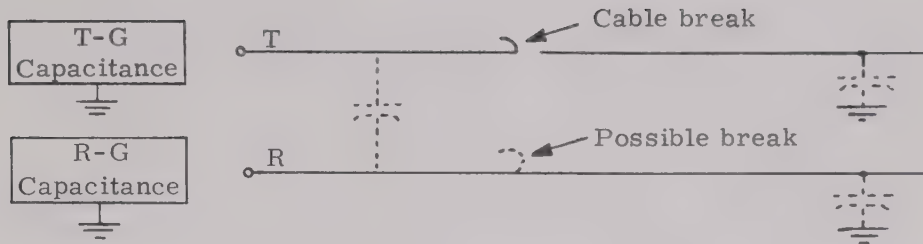


Figure 7-21. Measuring Distance to a Break (Open) in a Cable Pair

NOTE

The following procedure describes the method for finding a break or open in a cable pair. First the Tip to Ring capacitance is measured to check that the measured capacitance is normal for the cable length. A reading lower than normal indicates the cable pair is broken. Next, the Tip to Ground and Ring to Ground capacitance is measured to check if one or both wires are broken. If the readings are unequal, only one wire is broken. The chart shown in Figure 7-22 is used to locate the distance to the broken wire.

PROCEDURE TO FIND THE DISTANCE TO A BREAK IN A CABLE PAIR

STEP	PROCEDURE
1	Measure the Tip to Ring capacitance of the cable pair. If the reading is much lower than normal for the total cable length (see Table 7-3 or Figure 7-23), it is likely that one or both wires of the cable pair are broken (open).
2	Use Table 7-3 or Figure 7-23 to locate the break. e.g.: If the cable length is 29,000 feet and the cable pair capacitance is $.083\mu\text{F}/\text{mile}$, the total capacitance (from Table 7-3) is $.456\mu\text{F}$. However, if the display readout is .096 for example, it indicates a cable break at a distance of approximately 6100 feet.
3	To verify whether one or both wires of the cable pair are broken, measure the capacitance from Tip to Ground and Ring to Ground. If the readings are approximately equal, it is probable that both wires are broken. If the readings are unequal, the lower reading indicates the wire with the break. Use the distance-to-fault chart, Figure 7-22, to locate the break. e.g.: If the Tip to Ground capacitance is $.025\mu\text{F}$ and the Ring to Ground capacitance is $.075\mu\text{F}$, the wire connected to the Tip is broken. The distance to the break is found using Figure 7-22 as follows: - Locate $.025\mu\text{F}$ on the vertical scale (smaller reading). - Locate $.075\mu\text{F}$ on the horizontal scale (larger reading). - Note where lines from these points cross on the graph (.3 line for this example). - Break location is $.3 \times$ total cable length. <u>NOTE</u> The above procedure is valid only if there is no capacitance other than cable capacitance. The presence of ringer capacitors, bridged taps, etc., will cause erroneous results.

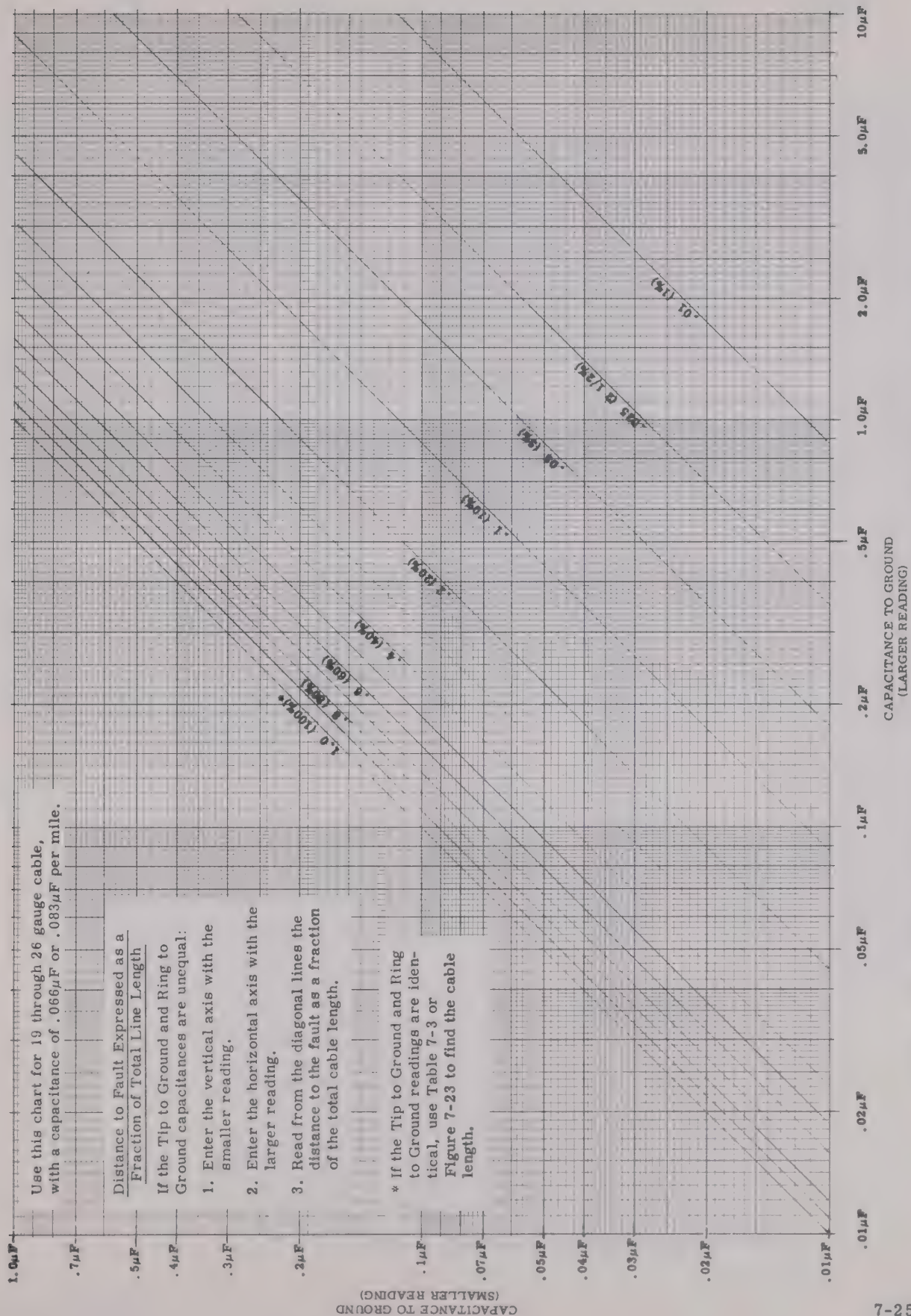


Figure 7-22. Distance to Fault Expressed as Fraction or Percentage of Total Cable Pair Length

NOMINAL
LO CAP.
CABLE

Table 7-3. CABLE LENGTH (FEET) CONVERSION
FROM MCA CAPACITANCE READING
(TIP TO RING MEASUREMENT)

NOMINAL
HI CAP.
CABLE

μF	MCA Reading	Cable Pair Mutual Capacitance (μF per Mile)													
		.062	.064	.066	.069	.070	.072	.074	.079	.080	.082	.083	.084	.086	.102
TENTHS	.100	8516	8250	8000	7652	7543	7333	7135	6684	6600	6439	6361	6286	6140	5176
	.200	17032	16500	16000	15304	15086	14666	14270	13368	13200	12878	12722	12572	12280	10352
	.300	25548	24750	24000	22956	22629	21999	21405	20052	19800	19317	19083	18858	18420	15528
	.400	34064	33000	32000	30608	30172	29332	28540	26736	26400	25756	25444	25144	24560	20704
	.500	42580	41250	40000	38260	37715	36665	35675	33420	33000	32195	31805	31430	30700	25880
	.600	51096	49500	48000	45912	45258	43998	42810	40104	39600	38634	38166	37716	36840	31056
	.700	59612	57750	56000	53564	52801	51331	49945	46788	46200	45073	44527	44002	42980	36232
	.800	68128	66000	64000	61216	60344	58664	57080	53472	52800	51512	50888	50288	49120	41408
	.900	76644	74250	72000	68868	67887	65997	64215	60156	59400	57951	57249	56574	55260	46584
HUNDREDTHS	.010	852	825	800	765	754	733	714	668	660	644	636	629	614	518
	.020	1703	1650	1600	1530	1509	1467	1427	1337	1320	1288	1272	1257	1228	1035
	.030	2555	2475	2400	2296	2263	2200	2141	2005	1980	1932	1908	1886	1842	1553
	.040	3406	3300	3200	3061	3017	2933	2854	2674	2640	2576	2544	2514	2456	2070
	.050	4258	4125	4000	3826	3772	3667	3568	3342	3300	3220	3180	3143	3070	2588
	.060	5110	4950	4800	4591	4526	4400	4281	4010	3960	3864	3817	3772	3684	3106
	.070	5961	5775	5600	5356	5280	5133	4995	4679	4620	4507	4453	4400	4298	3623
	.080	6813	6600	6400	6122	6034	5866	5708	5347	5280	5151	5089	5029	4912	4141
	.090	7664	7425	7200	6887	6789	6600	6422	6016	5940	5795	5725	5657	5526	4658
THOUSANDTHS	.001	85	83	80	77	75	73	71	67	66	64	64	63	61	52
	.002	170	165	160	153	151	147	143	134	132	129	127	126	123	104
	.003	255	248	240	230	226	220	214	201	198	193	191	189	184	155
	.004	341	330	320	306	302	293	285	267	264	258	254	251	246	207
	.005	426	413	400	383	377	367	357	334	330	322	318	314	307	259
	.006	511	495	480	459	453	440	428	401	396	386	382	377	368	311
	.007	596	578	560	536	528	513	499	468	462	451	445	440	430	362
	.008	681	660	640	612	603	587	571	535	528	515	509	503	491	414
	.009	766	743	720	689	679	660	642	602	594	580	573	566	553	466

HOW TO USE THE CHART

Add cable length values from each group above (tenths, hundredths, and thousandths), using the column for the particular cable pair mutual capacitance.

Example: If MCA capacitance reading is $.645\mu\text{F}$ (Tip to Ring) and cable mutual capacitance is $.083\mu\text{F}$ per mile, total cable length is found by adding lengths shown for .600, .040, and .005 (equal to $.645\mu\text{F}$). From the .083 column above, this is $38,166 + 2,544 + 318 = 41,028$ feet.

NOTE

Any capacitance due to buildout capacitors, ringer capacitors, etc. must be subtracted from the measured capacitance to obtain an accurate cable length reading. This chart is accurate only if the Tip to Ground and Ring to Ground capacitance readings are approximately equal (say, within $\pm 10\%$). The cable manufacturers' tolerance of the cable pair mutual capacitance figure (e.g. $.083\mu\text{F}$ per mile) is typically $\pm .004\mu\text{F}$, which is approximately ± 254 feet for $.083\mu\text{F}$ cable, and ± 320 feet for $.066\mu\text{F}$ cable at a cable temperature of 55°F (12.8°C). For a cable temperature of 0°F (-17.8°C) the mutual capacitance is decreased by 2%, while at 110°F (43°C) it is increased by 2%.

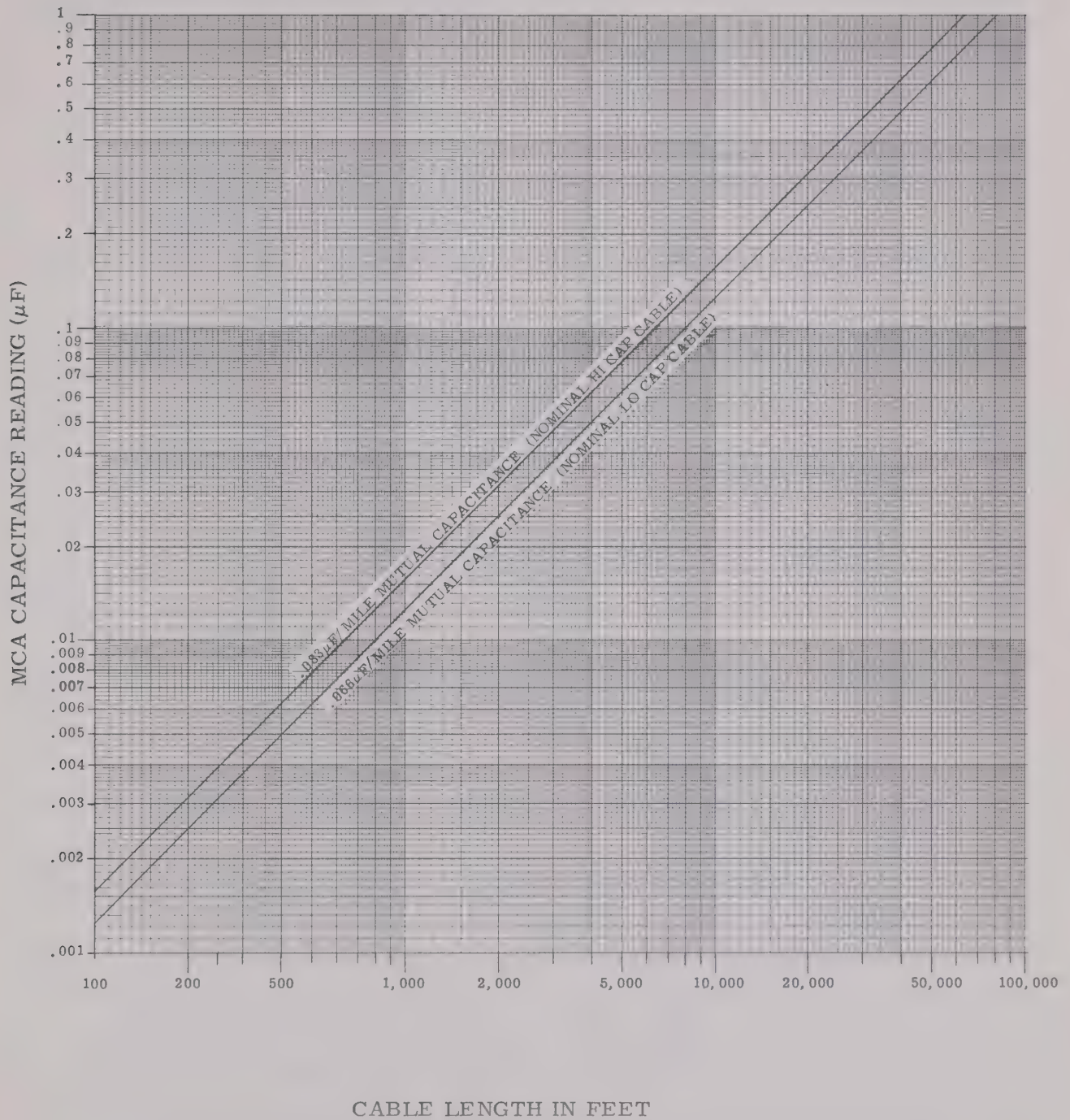


Figure 7-23. Chart for Converting MCA Capacitance Reading to Cable Length in Feet (for .083 and .066 μ F cable)

7.03 PERFORMANCE VERIFICATION/CALIBRATION

(A) Introduction

The following performance check enables the user to verify that the Multimeter Cable Analyzer measurement function meets the design specifications. This check may be performed upon installation of the equipment (prior to use), periodically, or when failure of the measurement function is suspected.

(B) Test Equipment Required

Table 7-4 lists the test equipment required for the performance check.

Standard patch cords, adapters, and test leads are not listed. Equivalent test equipment may be used if the accuracy equals or exceeds that of the equipment listed.

Table 7-4. List of Test Equipment

TRUE RMS VOLTMETER: Fluke 931B,
Level Accuracy: $\pm 0.02\%$ or better.
DC VOLTMETER: Fluke 871A,
Level Accuracy: $\pm 0.02\%$ or better.
AUDIO OSCILLATOR: HP236A,
Level Accuracy: ± 0.2 dBm.
POWER SUPPLY: HP721A,
Variable Output: 0 to 30V dc.
RESISTOR: 600 Ω , 1%
CAPACITOR: 2 μ F, 1%

SHARED ACCESS CHECK

STEP	PROCEDURE
1	Insert an open-circuit plug in the INPUT jack of the Multimeter Cable Analyzer Control Panel.
2	Verify that the BUSY indicator lights on the Multimeter Cable Analyzer Control Panel at all other test locations.

ACCURACY CHECKS

STEP	PROCEDURE
	<u>DC Voltage:</u>
1	Press the T-R and the V dc pushbuttons on the Multimeter Cable Analyzer Control Panel.
2	Connect the HP721A power supply to the INPUT jack on the Multimeter Cable Analyzer Control Panel using a patch cord wired tip and ring. Set the power supply output voltage as close as possible to +30V, as read on the power supply front panel meter.
3	Connect the Fluke 871A dc voltmeter to measure the output of the power supply. Set the voltmeter digits to +30.00, and to read a null within 0.1V.
4	Fine adjust the power supply output voltage to obtain a null on the Fluke 871A voltmeter. Verify that the Multimeter Cable Analyzer Display readout is +30.0 $\pm$ 0.1V.
5	*Press the T-G pushbutton on the Multimeter Cable Analyzer Control Panel, and repeat steps 2 through 4 using a patch cord wired tip and ground.
6	*Press the R-G pushbutton, and repeat steps 2 through 4 using a patch cord wired ring and ground.

*Check that the ground reference terminal (pin P) at the rear of the Control Panel has been connected to the desired frame ground point.

ACCURACY CHECKS (CONT.)

STEP	PROCEDURE
	<u>DC Current:</u>
1	Press the T-R and mA dc pushbuttons on the Multimeter Cable Analyzer Control Panel.
2	Connect a 600 ohm ($\pm 0.1\%$) resistor in series with the positive output of the HP871A power supply and the tip connection to the INPUT jack on the Multimeter Cable Analyzer Control Panel. Connect the power supply negative terminal to the ring connection of the INPUT jack.
3	Set the power supply output voltage as close as possible to +6V, as read on the power supply front panel meter.
4	Connect the Fluke 871A dc voltmeter to measure the output of the power supply. Set the voltmeter digits to +6.000, and to read a null within 0.01V.
5	Fine adjust the power supply output voltage to obtain a null on the Fluke 871A voltmeter. Verify that the Multimeter Cable Analyzer Display readout is $10.0 \pm 0.2\text{mA}$.

ACCURACY CHECKS (CONT.)

STEP	PROCEDURE
	<u>AC Voltage:</u>
1	Press the T-R and V ac pushbuttons on the Multimeter Cable Analyzer Control Panel.
2	Connect the output of the HP236A audio oscillator to the INPUT jack on the Multimeter Cable Analyzer Control Panel.
3	Connect the Fluke 931B rms voltmeter to measure the oscillator output voltage. Set the voltmeter digits at 1.0000, and to read a null within 1%.
4	Set the oscillator frequency to 1 KHz. Adjust the oscillator output level for a null on the rms voltmeter.
5	Verify that the Multimeter Cable Analyzer Display readout is $1.0 \pm 0.2\text{V ac}$.

ACCURACY CHECKS (CONT.)

STEP	PROCEDURE
	<u>Resistance ($k\Omega$):</u>
1	Press the T-R and $k\Omega$ pushbuttons on the Multimeter Cable Analyzer Control Panel.
2	Short the INPUT terminals and check that the display reads .000 $k\Omega$. If not, adjust the $k\Omega$ ZERO ADJ at the rear of the Control Panel.
3	Connect a 600 ohm ($\pm 0.1\%$) resistor to the INPUT jack on the Multimeter Cable Analyzer Control Panel. Use tip and ring connections.
4	Verify that the Multimeter Cable Analyzer Display readout is .600 $\pm .003k\Omega$.

ACCURACY CHECKS (CONT.)

STEP	PROCEDURE
	<u>Resistance ($M\Omega$):</u>
1	Press the T-R and $M\Omega$ pushbuttons on the Multimeter Cable Analyzer Control Panel.
2	Connect a resistor between 100 $k\Omega$ and 10 $M\Omega$ (0.1% accuracy) to the INPUT jack (tip and ring contacts) on the Multimeter Cable Analyzer Control Panel.
3	Verify that the Multimeter Cable Analyzer Display readout is the nominal resistor value $\pm$ the tolerance.

ACCURACY CHECKS (CONT.)

STEP	PROCEDURE
	<u>Capacitance:</u>
1	Press the T-R and μF pushbuttons on the Multimeter Cable Analyzer Control Panel.
2	Connect a 2 μF ($\pm 0.1\%$) capacitor (not an electrolytic, polarized type) to the INPUT jack (tip and ring contacts) on the Multimeter Cable Analyzer Control Panel.
3	Verify that the Multimeter Cable Analyzer Display readout is 2.0 $\pm 0.02\mu F$.

(C) Calibration

The following calibration procedure should be performed if the results of the previous accuracy checks are abnormal. If abnormal results are still obtained after calibration, refer to the troubleshooting instructions in paragraph 7.05.

7.04 THEORY OF OPERATION

Refer to Figure 7-23 at the end of this section. The test signal to be measured is patched to the INPUT jack on the Multimeter Cable Analyzer Control Panel. Pushbuttons are provided for selecting an ac or dc voltage, direct current, resistance, or capacitance measurement function.

The test signal is applied to the measuring circuits through a termination switch, which is open except for current measurements. When current is being measured, the termination switch connects a 1 ohm shunt resistor across the input.

The pushbutton switches for function selection control the inputs to an encoder to develop a 3-line binary output representative of the function selected. This output is applied to a function control decoder, control logic circuits, and function relay drivers on PC Board 9270-2 in the Equipment Shelf. The relay drivers operate the appropriate relays for the measurement function selected.

For dc voltage measurements, the voltage to be measured is applied to a divider which attenuates the input by 100:1. The resulting voltage is applied to a switchable gain buffer amplifier, U12, which has a gain of 10 for input voltages up to 99.9V or a gain of 1 for input voltages between 90V and 300V.

For ac voltage measurements, the voltage to be measured is first attenuated as for dc voltages and then rectified by a

full wave averaging rectifier. The resulting dc voltage is applied to buffer amplifier U12. An AC CAL control varies the gain of the averaging rectifier to permit calibration for ac voltage measurements.

The dc output voltage from U12 is fed through a Vdc CAL control to a dual-slope analog to digital converter on PC Board 9270-1. The output of the A/D converter is a number of pulses proportional to the measured unknown.

The pulses from the A/D converter are applied to a comparator along with timing signals from the Timer Module. The comparator output is fed through an optical isolator to the gating and autoranging circuits. The optical isolator is necessary because the dc operating voltages for PC Board 9270-1 are floating (not referenced to ground).

The comparator output is processed by gating and autoranging circuits to obtain the digital signals necessary to drive the counters. The BCD (binary coded decimal) outputs from the counters are decoded by the decoder/drivers located in the Display Module. The outputs from the decoder/drivers cause the appropriate decimal digit to light.

Additional digital logic circuits develop the control signals required to blank the display digits and light the appropriate polarity sign.

Direct current measurements are accomplished by switching in a 1-ohm resistor at the input of the Control Panel. The resulting voltage drop across the 1-ohm resistor is proportional to the current being measured. This voltage is then applied directly to buffer amplifier U12, which has a gain of 100 for input currents up to 99.9mA or a gain of 10 for input currents between 90mA and 200mA.

A circuit breaker (1 amp) is used to protect the current measuring circuit from overload.

Loop resistance measurements are made by applying a 1mA constant current from a 160V dc supply through the resistance to be measured. The resulting voltage is proportional to the resistance value in kilohms.

Leakage resistance measurements are made by applying a 10 or 100 μ A current from a 160V dc constant current source through the resistance to be measured.

The resulting voltage drop is proportional to the resistance being measured. This voltage is processed in the same manner as for dc voltage measurements and the results displayed in megohms.

An active filter, U11, is used for the AC Volts, DC Volts, and resistance measurement functions. The filter provides 60 dB rejection at 50 Hz, which is increased to 90 dB at 200 Hz and above.

MULTIMETER CABLE ANALYZER CALIBRATION

STEP	PROCEDURE
1	Switch the power off at the power Supply in the Equipment Shelf. Remove PC Board 9270-2 from the Equipment Shelf. Mount the PC Board on the extender board (stored behind the Timer), then install the extender board in the slot. Switch the power on.
2	Connect the digital voltmeter to the -15V test point and COM on the front panel of PC Board 9270-2. Check that the voltage is -15.00 $\pm$ 5mV. If outside this tolerance, adjust the -15V ADJ control on the PC Board for the correct reading.
3	Switch the system power off. Remove the PC Board from the extender board. Install the PC Board in its slot. Switch the system power on.
4	Select the Vdc pushbutton on the Control Panel. Apply a short to the INPUT jack and note that the display is 00.0V dc. If not, adjust the Vdc ZERO ADJ control on the front panel of PC Board 9270-1 for the correct reading. Remove the short at the INPUT jack.
5	Patch the -48V office battery (talk battery) to the INPUT jack. Using the Fluke 871A differential voltmeter (or a digital voltmeter calibrated to 0.1% accuracy), measure the battery voltage and note the reading. Compare this reading with that on the Multimeter Cable Analyzer display. If a difference is noted, adjust the Vdc CAL control on the front panel of PC Board 9270-1 for an identical reading. Remove the battery from the INPUT jack.
6	Select the k Ω pushbutton on the Control Panel. Apply a short at the INPUT jack and check that the Multimeter Cable Analyzer display is .000k Ω . If not, adjust the k Ω ZERO ADJ control at the rear of the Control Panel for the correct display. Remove the short from the INPUT jack.

A k_n ZERO ADJ control at the rear of the Control Panel is used to nullify the effects of the cable resistance between the Control Panel and the Equipment Shelf. This is done by first pressing the k_n pushbutton and then shorting the input at the panel and adjusting the ZERO ADJ control for a .000 k_n display.

Capacitance measurements are made by charging the capacitance to be measured, and then discharging it through integrator U15 of the A/D converter circuit. The discharge time is proportional to the value of the capacitance being measured, and produces a particular number of pulses at the A/D converter output. The pulses are applied to the counter and decoder/driver circuits to provide a display of the capacitance value in microfarads.

7.05 TROUBLESHOOTING

The troubleshooting chart, Table 7-6, is used to isolate a fault in the Control Panel, Displays, or the Measuring Module. The Signal Flow Chart, Figure 7-25, may also be used for troubleshooting. The test equipment required is a digital voltmeter.

7.06 REMOVAL AND REPLACEMENT INSTRUCTIONS

(A) Some measuring modules are fitted with an interconnecting cable between the two PC Boards (Models 9270-1 and 9270-2). This is the case for DTMS Equipment Shelf Mother Boards with an Issue No. of 06 or lower. Be careful that this cable is not under tension when removing either PC Board from the front panel.

(B) The following procedure is used to remove or replace the PC Board in the Multimeter Cable Analyzer Control Panel.

1. Switch the system power OFF.
2. Remove four screws from the cover, then pull it straight back to detach the cover from the PC board connector inside the Control Panel.
3. Remove the retaining ring which secures the BUSY indicator. Press the indicator

backwards to remove it from the front panel.

4. Remove one screw to detach the INPUT jack from the front panel.
5. Remove the PC board and the attached parts from the Control Panel.

NOTE

The BUSY indicator and INPUT jack are hard-wired to the PC board.

6. Install the new PC board in the Control Panel so that the pushbutton switches extend through the front panel.
7. Press the BUSY indicator through the grommet in the front panel and secure it with the retaining ring.
8. Secure the INPUT jack to the front panel with one screw.
9. Install the cover on the Control Panel so that the PC board connector is properly mated with the socket on the cover.
10. Secure the cover using four screws.

7.07 PARTS LIST

Table 7-5 lists the WILTRON part numbers for the replaceable assemblies used with the Multimeter Cable Analyzer measurement function.

Table 7-5. Parts List for Multimeter Cable Analyzer Measurement Function

<u>DESCRIPTION</u>	<u>WILTRON PART NO.</u>
Multimeter Cable Analyzer	
Control Panel (Complete)	9370
Measuring Module	9270
PC Board, Analog to Digital Converter	9270-1
PC Board, MCA Input Circuits	9270-2
Multi. Cable Analyzer Display Module (see note)	9477 or 9487
Display Housing, Panel, Close View or Distant View (see note)	9461, 9462 or 9463

Troubleshooting

NOTE: The Model 9477 Multimeter Cable Analyzer Display Module is housed in Panel Display Housing Model 9461 or Close View Display Housing Model 9462. The Model 9487 Display Module is housed in Distant View Housing 9463. Two sizes of nixie display tubes are used in the Display Modules. The Model 9477 Display Module uses display tubes with a 1/2-inch

character height, and the Model 9487 Display Module uses display tubes with an 8/10-inch character height.

7.08 FUNCTIONAL BLOCK DIAGRAM

Figure 7-24 following is a functional block diagram for the Multimeter Cable Analyzer measurement function.

Table 7-6. Multimeter Cable Analyzer Troubleshooting Chart

STEP	PROCEDURE	ACTION									
		IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL								
1.	a. Switch the system power off. Unplug PC Board 9270-1 from the Equipment Shelf and mount it on the extender board (stored behind the Timer Module). <u>CAUTION</u> Some measuring modules are fitted with an inter-connecting cable between the two PC Boards (Models 9270-1 and 9270-2). Be careful that this cable is not under tension when removing either PC Board from the Equipment Shelf. b. Plug the extender board into the slot. Switch the system power ON. c. Using a digital voltmeter, check that the voltages between the following test points and COM on PC Board 9270-1 are present: <table><tr><td><u>Test Point</u></td><td><u>Reading</u></td></tr><tr><td>-15V</td><td>-15V</td></tr><tr><td>TP1</td><td>+15V</td></tr><tr><td>TP2</td><td>+160V</td></tr></table>	<u>Test Point</u>	<u>Reading</u>	-15V	-15V	TP1	+15V	TP2	+160V	Proceed with step 3. Proceed with step 2. Proceed with step 2.	Proceed with step 2. PC Board 9270-2 is faulty.
<u>Test Point</u>	<u>Reading</u>										
-15V	-15V										
TP1	+15V										
TP2	+160V										

Table 7-6. Multimeter Cable Analyzer Troubleshooting Chart (Cont.)

STEP	PROCEDURE	ACTION	
		IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
2.	a. Press the Vdc and T-R push-buttons. Check that the dc voltage at terminals 8, 14, L, and D (common) on PC Board 9270-1 is as shown in Table 7-7 for the various functions. Repeat the measurements between terminals U, S, V, and D (common) on PC Board 9270-2.	Proceed with step 3.	PC Board 9270-1 or 9270-2 is faulty.
3.	a. Press the Vdc and T-R push-buttons. b. Connect -48V to the INPUT jack. c. Connect a digital voltmeter (with 0.1% accuracy) to measure the -48V input. d. Check that the voltage between terminals R and S at the rear of the Control Panel is equal to the digital voltmeter reading at the INPUT jack.	Proceed with step 4.	Control Panel is faulty.
4.	a. Switch the system power OFF. Unplug PC Board 9270-2 from the Equipment Shelf and mount it on the extender board. Return PC Board 9270-1 to its slot. b. Plug the extender board into the slot. Switch the system power ON. c. Check that the voltage between terminals E and D on PC Board 9270-2 is equal to the digital voltmeter reading at the INPUT jack.	Proceed with step 5.	Faulty wiring between Control Panel and PC Board 9270-1.
5.	a. Check that the voltage between the ANALOG OUTPUT and COM test points is one-tenth that of the voltage at the INPUT jack (e.g. 4.80 volts for 48.0V input).	Proceed with step 6.	PC Board 9270-2 is faulty.

Table 7-6. Multimeter Cable Analyzer Troubleshooting Chart (Cont.)

STEP	PROCEDURE	ACTION	
		IF INDICATION IS NORMAL	IF INDICATION IS ABNORMAL
6.	a. Check that the BCD lines at the terminals on PC Board 9270-1 are at the proper logic levels for the voltage applied to the INPUT jack. See the example (step 6) in the introduction to Figure 2-8 in Section II.	Proceed with step 7.	PC Board 9270-1 is faulty.
7.	a. Check for the proper logic levels as in step 6a. at the Display Module terminals.	Display Module is faulty.	Wiring between PC Board 9270-1 and Display Module is faulty.

Table 7-7. MCA Function Selection Logic States

FUNCTION	TERMINAL			PC BOARD
	8	14	L	← 9270-1
	U	S	V	← 9270-2
V dc	L	H	H	
V ac	L	L	H	
k Ω	L	H	L	
M Ω	H	L	H	
μF	H	H	L	
mA dc	H	H	H	

H = approximately 4.8V dc
L = approximately 0V dc

7.09 SIGNAL FLOW CHART

The Signal Flow Chart, Figure 7-25, can be used for troubleshooting the Multimeter Cable Analyzer measurement function,

and may also be used when checking the cabling connections between the Control Panel, Equipment Shelf, and Display Housing.

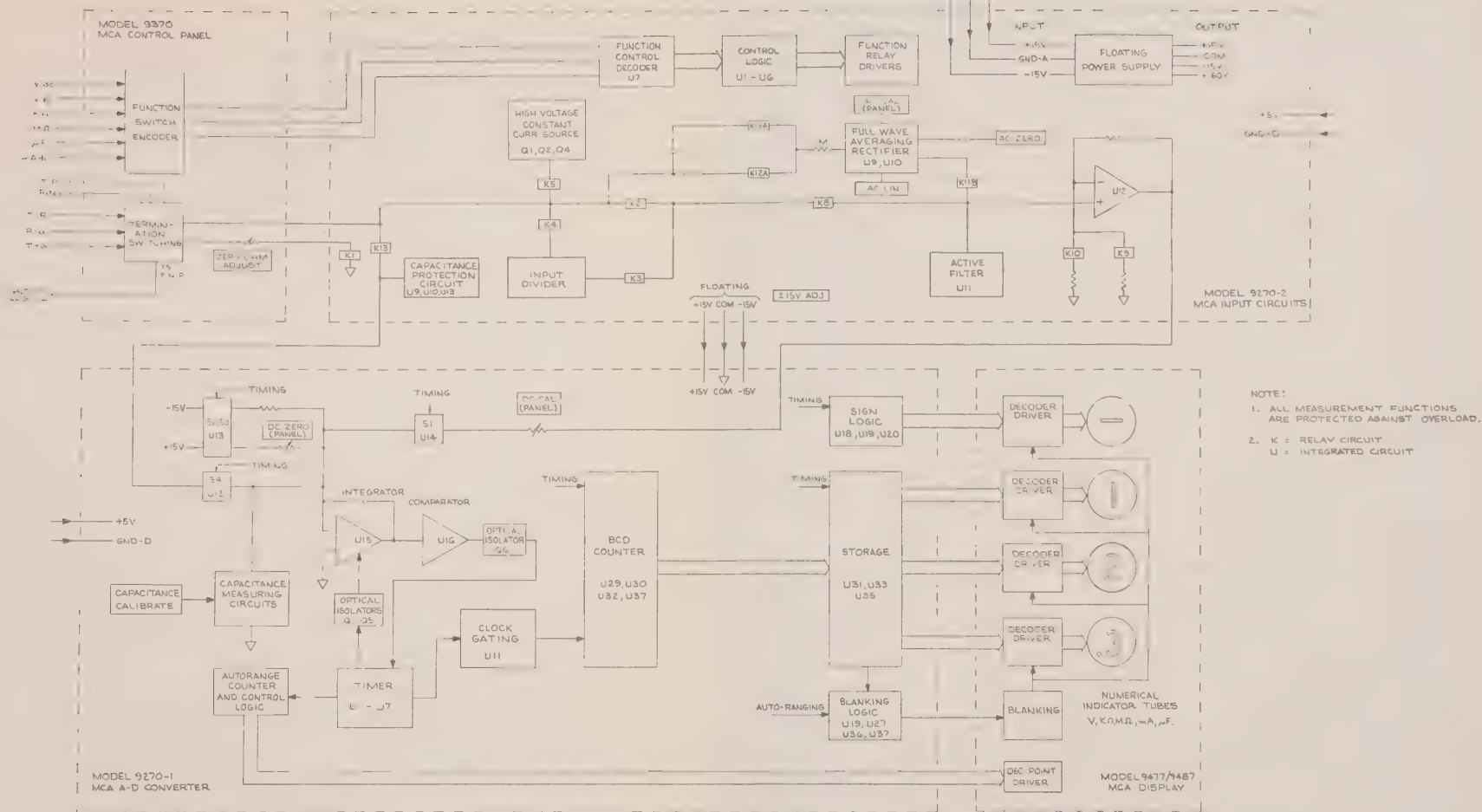
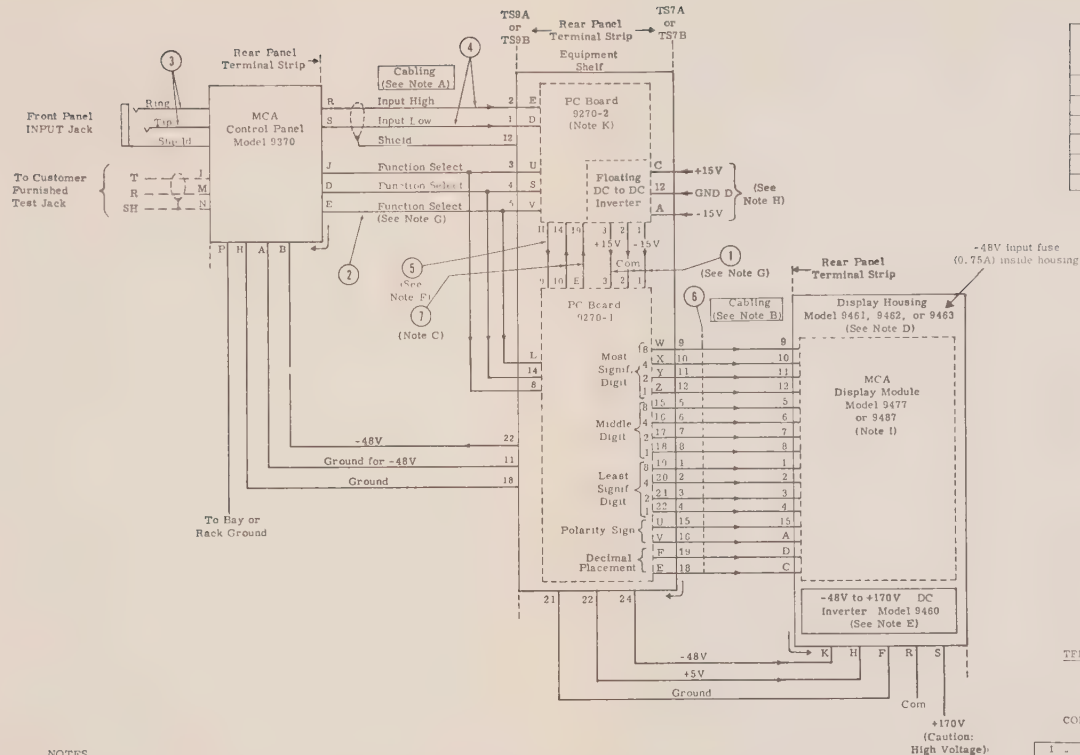


Figure 7-24. Functional Block Diagram



NOTES

- A Cabling between Control Panel and Equipment Shelf may be up to 250 ft. long.
- I Cabling between Equipment Shelf and Display Housing may be up to 1000 ft. long.
- C Two control lines for autoranging. See Table 7-10.
- D Display Housing Model 9461 may house up to 2 Display Modules. Display Housing Models 9462 and 9463 may house up to 3 Display Modules.
- F Only one DC Inverter required for up to 3 Display Modules.
- F Signal measured at ANALOG OUTPUT test point on front panel of PC Board 9270-2.
- G Three binary control lines for function selection. See Table 7-8.
- H Voltages are supplied from Power Supply in Equipment Shelf through traces on motherboard.

- I All integrated circuits on the Display Module PC Board are mounted in sockets to enable easy replacement.
- J The following integrated circuits on PC Board 9270-1 are mounted in sockets:

I.C.	TYPE	FUNCTION
U20	7400N	Polarity sign logic
U28	7486N	Decimal placement control
U31, U33, U35	7475N	Counter storage
U36, U37	7400N	Counter output
U42	7442N	Function select encoder

- K The following integrated circuits on PC Board 9270-2 are mounted in sockets:

I.C.	TYPE	FUNCTION
U1	7486N	Autoranging
U7	7442N	Function select decoder

Table 7-8. MCA Function Selection Logic States

FUNCTION	TERMINAL			PC BOARD
	B	14	N	
Vdc	L			
Vac	L	L		
kA	L	B		
mA	H			1. 0V dc
μF	H	H		
mA dc	H	H		

TERMINAL DESIGNATIONS

CONTROL PANELS AND DISPLAYS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	C	D	E	F	G	H	I	J	K	L	M	N	P
Q	R	S	T	U	V	W	X	Y	Z					

(Terminals G, I, O, and Q omitted)

EXTENDER BOARD

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	R	S	T	U	V	W	X	Y
Z																						

(Terminals G, I, O, and Q omitted)

Figure 7-25. Multimeter Cable Analyzer Signal Flow Chart, Sheet 1 of 2

Table 7-9. BCD Logic Levels for Decimal Digits at Terminals on PC Board 9270-1 and Display Module.

ASSEMBLY TERMINAL STRIP	TERMINAL DESIGNATION OF BCD LINES				IDENTIFICATION
	8	1	1	1	
PC Board 9270-1	3				Most Significant Digit
	1	1			Middle Digit
	1	0	0	0	Least Significant Digit
					Polarity Sign
					Decimal Placement
Display Module	3	1	1	1	Most Significant Digit
	5	0	1		Middle Digit
	1	2		1	Least Significant Digit
					Polarity Sign
					Decimal Placement

ASSEMBLY TERMINAL STRIP	TERMINAL DESIGNATION OF BCD LINES				IDENTIFICATION
	8	1	1	1	
BCD Logic Levels	0	0	0	0	Decimal 0
	0	0	1		Decimal 1
	0	0	1	1	Decimal 2
	0	0	1	1	Decimal 3
	0	1	0		Decimal 4
	0	1	0	1	Decimal 5
	0	1	1	0	Decimal 6
	0	1	1	1	Decimal 7
	1	0	0		Decimal 8
	1	0	0	1	Decimal 9
	0	1			
	1	0			
	1	1			No Polarity Sign
	0	1			.XXX Decimal Placement
	0	0			X.XX Decimal Placement
	1	1			XX.X Decimal Placement
	1	0			XXX Decimal Placement

0 = 0V approx.
1 = 3.5V approx.

HOW TO USE THE CHART

1. Use a digital voltmeter for the measurements.
 2. Make the checks in the order shown below. If a particular voltage is abnormal, but the previous measurements are normal, it is likely that the PC Board between these two points is faulty.
- NOTE:** On new installations, the cabling should be checked first for wiring errors.
3. If a spare PC Board of the same model is available, it can be substituted for the suspect board to see if the fault is cleared.

TROUBLESHOOTING CHECKS

POINT	READING	REMARKS
①	+15V, -15V	Measured at floating test points on front panel of PC Board 9270-1.
②	See Table 7-8.	Controls selected: T-R, each measurement function in turn starting with Vdc.
③	-48V dc	Apply -48V dc at Control Panel INPT T jack (tip and ring). Controls selected: T-R, Vdc.
④	-48V dc, input high to input low	Same as above.
⑤	-4.8V dc approx. to common	Same as above.
⑥	See Table 7-9.	Same as above.
⑦	See Table 7-10.	Two autoranging control lines that operate relays K1 through K12 on PC Board 9270-2. The relays select the proper autoranging for each of the MCA measurement functions (Vdc, Vac, ka, Ma, μF , and mA dc).

Table 7-10. MCA Autoranging Control

FUNCTION	ALTO. RANGES	RELAYS ON PC BOARD 9270-2												LOGIC LEVELS ON PC BOARD TERMINALS	
		K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	10	1
Vdc	0-99.9 90-999	X	-	X	-	-	-	X	X	-	-	-	-	0	1
Vac	0-99.9 90-999	X	-	X	-	-	-	-	X	-	X	-	-	0	1
ka	0-99.9 90-999	-	X	-	X	X	-	X	X	-	-	-	-	1	1
Ma	0-99.9 90-999	-	-	X	X	X	-	X	X	-	-	-	-	0	1
μF	0-99.9 90-999	X	-	-	-	-	-	X	-	-	-	X	X	1	1
mA dc	0-99.9 90-200	X	X	-	-	-	-	X	X	X	-	-	-	0	1

X = relay energized (closed)
- = relay de-energized (open)

0 = 0V dc approx.
1 = 3.5V dc approx.

Figure 7-25. Multimeter Cable Analyzer Signal Flow Chart, Sheet 2 of 2

SECTION VIII

MODEL 9104 TIMER MODULE

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8.05	TROUBLESHOOTING . . .	8-2
8.06	REMOVAL AND RE- PLACEMENT	8-2
8.07	FUNCTIONAL BLOCK DIAGRAM	8-2
8.08	SIGNAL FLOW CHART . .	8-2

8.02 OPERATION

There are no operating controls or indicators on the Timer Module.

8.01 DESCRIPTION

The Model 9104 Timer Module provides the various timing signals required by the Measuring Modules. The Timer Module is located in the center slot of the Equipment Shelf between the Side A and Side B slots.

The Timer Module is a plug-in PC Board with an attached front panel (see Figure 8-1). Test points are provided on the front panel for the basic 100 kHz timer signal and the 9 Hz display update signal.

An extender board is stored behind the Timer Module in the Equipment Shelf. The extender board allows access to the PC Board connector terminals of any of the Measuring Modules to make measurements when troubleshooting.

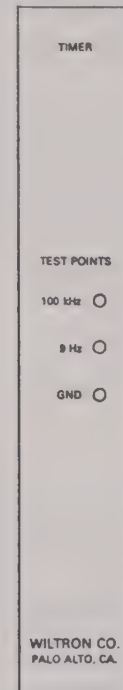


Figure 8-1. Timer Module

8.03 PERFORMANCE VERIFICATION/ CALIBRATION

There are no calibration adjustments for the Timer Module. The following procedure can be used to check the Timer Module for proper operation. This check may be performed upon installation of the equipment, or when failure is suspected. Check the Timer Module as follows.

PERFORMANCE VERIFICATION/CALIBRATION PROCEDURE

STEP	PROCEDURE
1	Switch the system power off. Remove the Timer Module from the Equipment Shelf and mount it on the extender board (stored behind the Timer Module in the Equipment Shelf).
2	Plug the extender board into the Timer Module slot in the Equipment Shelf.
3.	Turn the system power on.
4	Using an oscilloscope, Tektronix 503 or equivalent, observe the waveform at each terminal on the Timer Module as shown in Figure 8-2.
5	Connect a frequency counter (HP5245L, or equivalent) to the 100 kHz and GND test points on the Timer front panel. Check that the counter readout is 100 kHz $\pm$ 5 Hz.
6	Switch the system power off. Detach the Timer Module from the extender card.
7	Return the Timer Module to its slot in the Equipment Shelf.

8.04 THEORY OF OPERATION

Refer to the Timer functional block diagram, Figure 8-2. A crystal oscillator generates a 1 MHz signal which is applied through a buffer stage to a series of six decade dividers. The decade dividers produce output frequencies of 100 kHz, 10 kHz, 1 kHz, 100 Hz, 9 Hz, and 0.9 Hz. These frequencies are fed through clock gating circuits to develop the control signals required by the measurement module analog and digital circuits.

8.05 TROUBLESHOOTING

Use the troubleshooting chart, Table 8-1 to isolate a fault in the Timer Module. An oscilloscope and dc voltmeter are required for this procedure.

8.06 REMOVAL AND REPLACEMENT

Removal and replacement of the Timer Module is straight forward. When installing the Timer, it should be pushed firmly into the Equipment Shelf to ensure it is properly seated in the connector socket.

NOTE

The system power should be switched off when removing or installing the Timer Module.

8.07 FUNCTIONAL BLOCK DIAGRAM

Figure 8-2 is a functional block diagram of the Timer Module.

Table 8-1. Timer Module Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	a. Switch the system power off. Remove the Timer Module from the Equipment Shelf and mount it on the extender board.	Proceed with step 2.	Check the Power Supply (see paragraph 9.05 in Section IX).
	b. Plug the extender board into the Timer Module slot in the Equipment Shelf.		
	c. Turn the system power on. Measure +5V dc between terminals Z and Y (common) on the Timer Module.		
2.	Observe the waveform at each terminal on the Timer Module as shown in Figure 8-2.	Check for faulty cabling.	Timer Module is defective.

Block Diagram

SYSTEM TIMING SIGNALS ON TERMINALS AS INDICATED
(ALL LEVELS ARE 0 TO +3 BV)

100 kHz CLOCK OUTPUT

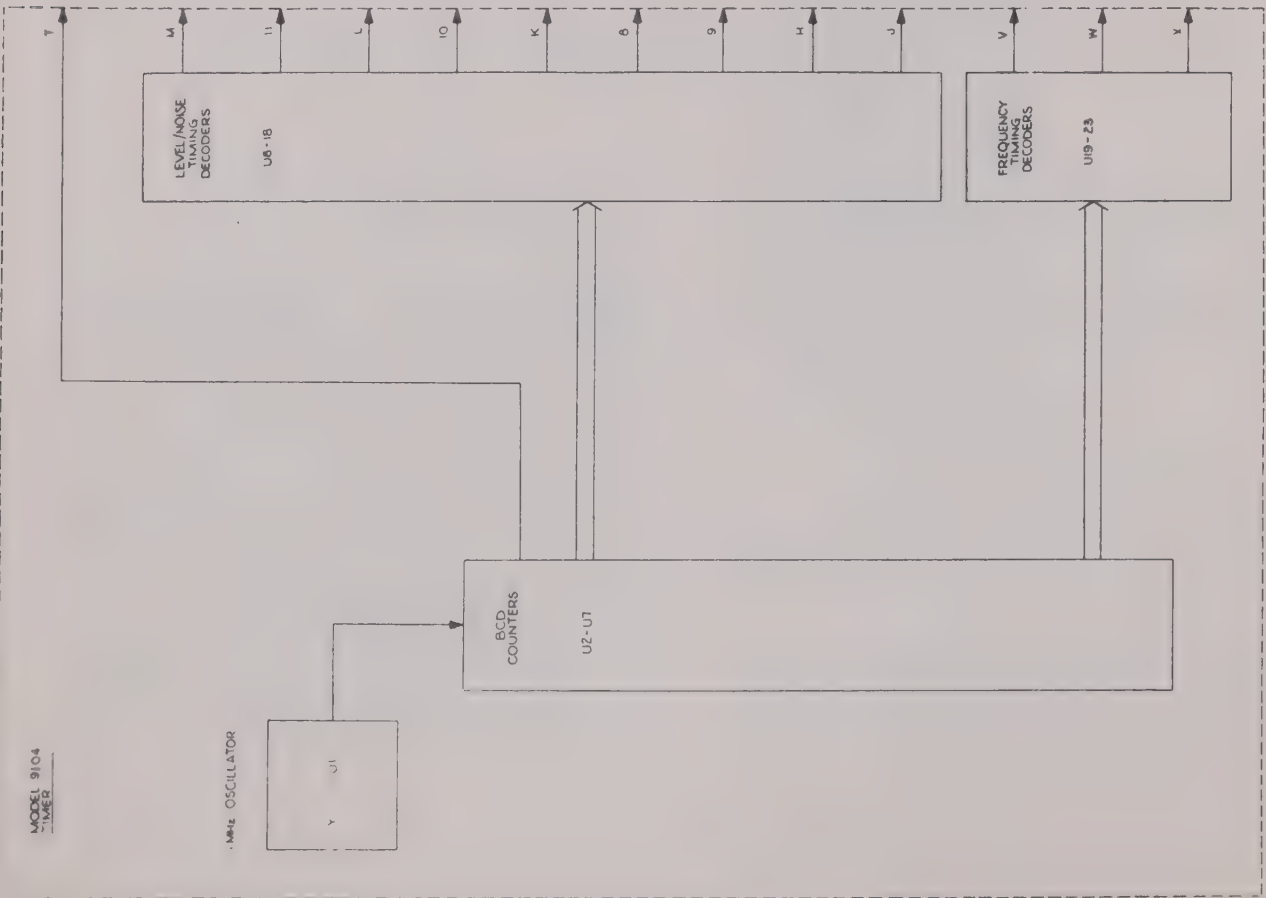
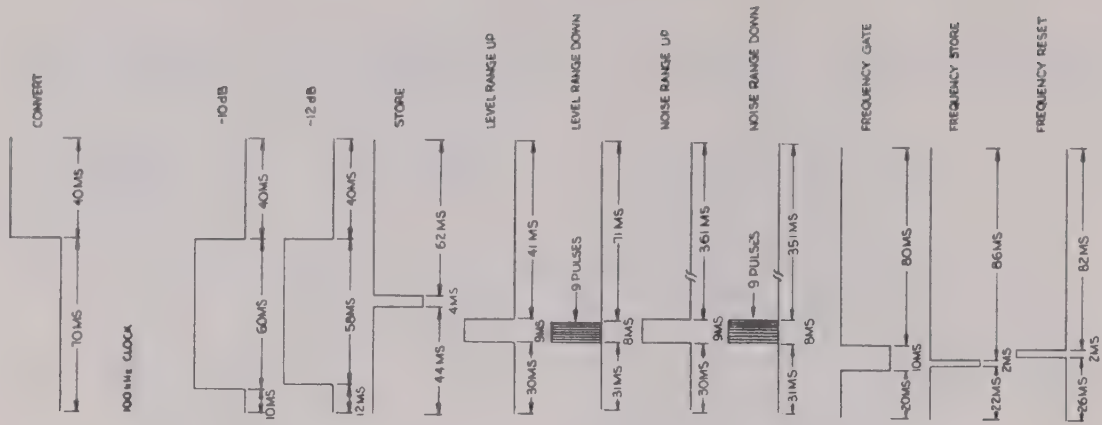


Figure 8-2. Model 9104 Timer Functional Diagram

SECTION IX

MODEL 9113 -48V POWER SUPPLY

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9.02	OPERATION	9-1
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9.05	TROUBLESHOOTING.....	9-3
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9.01 DESCRIPTION

The Model 9113 Power Supply, located at the left side of the Equipment Shelf, provides regulated supply voltages of +5V, +15V and -15V for the Control Panels, Display Modules, and Common Measurement Equipment. The Power Supply operates from an input between -42.5V and -52V dc (nominal -48V dc). Power requirements are 120 watts, or approximately 2.5 amperes at -48V dc.

The Power Supply consists of a plug-in PC Board with an attached front panel (see Figure 9-1). Mounted on the front panel are a power ON indicator, and a test point and an adjustment control for each of the power supply output voltages. A latch for the Equipment Shelf door is also mounted on the Power Supply front panel. The series regulator transistor for the +5V supply is mounted on the Equipment Shelf PC Board to provide an adequate heat sink. However, a "keep alive" low power series

regulator transistor is provided in the unit so that it can be tested under no-load conditions when removed from the Equipment Shelf.

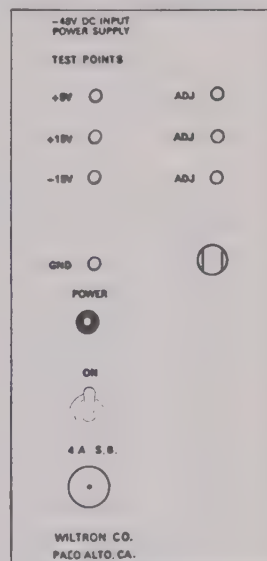


Figure 9-1. Model 9113 Power Supply

9.02 OPERATION

Table 9-1 describes the function of the operating controls and indicators on the front panel of the Model 9113 Power Supply. The function of the controls, indicators, and connectors provided for maintenance purposes is described in paragraph 9.03 of this section.

Table 9-1. Operating Controls and Indicators

POWER INDICATOR LAMP: lights when the Power Supply is providing power to the Control Panels, Display Modules, and Common Measurement Equipment.

9.03 PERFORMANCE VERIFICATION/CALIBRATION

The following procedure enables the user to verify that the Power Supply output voltages are within specifications. This check may be

Verification/Calibration
Procedure

PERFORMANCE VERIFICATION/CALIBRATION PROCEDURE

STEP	PROCEDURE
1	Connect the dc voltmeter (Fluke 871A or equivalent) to the -15V TEST and GND. test points on the power supply.
2	Turn on the system power and allow the equipment to warm up for approximately 30 minutes.
3	Adjust the dc voltmeter controls as follows: RANGE 100 NULL .1 Digits setting -15.000
4	Check that a meter null is obtained at $-15.000 \pm 75\text{mV}$. If necessary, adjust the -15V ADJ. control to obtain a null.
5	Transfer the dc voltmeter to the +15V TEST and GND. test points on the power supply.
6	Set the voltmeter digits to +15.000. Check that a meter null is obtained at $+15.000 \pm 75\text{mV}$. If necessary, adjust the +15V ADJ. control for a null on the meter.
7	Transfer the dc voltmeter to the +5V TEST and GND. test points.
8	Set the voltmeter RANGE control to 10, and the digits to +5.000.
9	Check that a meter null is obtained at $+5.000 \pm 50\text{mV}$. If necessary, adjust the +5V ADJ. control for a null.

performed upon installation of the equipment (prior to use) or when the unit has been repaired or failure is suspected. An accurate dc voltmeter, such as the Fluke 871A or equivalent is required for this check.

9.04 THEORY OF OPERATION

Refer to the power supply functional block diagram, Figure 9-2. The -48V dc input to the power supply is applied to an inverter stage through the power on/off switch and line fuse. The inverter stage "chops" the dc input to obtain a square-wave ac voltage which can be stepped up or down by the power transformer. The ac outputs from the four secondary windings are rectified and fed through series regulators to provide dc output voltages of +5V, +15V, and -15V. The +5V, -15V, and +15V supplies provide power for the Measuring Modules and Control Panels.

9.05 TROUBLESHOOTING

The Power Supply Troubleshooting Chart, Table 9-2, can be used to isolate a fault to a replaceable assembly. The only test equipment required is a dc voltmeter (Simpson 260 or equivalent).

9.06 REMOVAL AND REPLACEMENT INSTRUCTIONS

The following paragraphs provide instructions for removing and replacing the Model 9113 Power Supply. No special tools are required for this procedure.

(A) Removal

Remove the Power Supply from the Equipment Shelf as follows:

1. Set the power switch to the off position. Unplug the ac power cord.
2. Remove one screw from the front panel (left side) of the Power Supply.
3. Firmly grasp the handle at the top of the Power Supply and pull it straight out.

(B) Replacement

Replace or re-install the Power Supply in the Equipment Shelf as follows:

1. Line up the Power Supply PC Board with the top and bottom slots in the Equipment Shelf.
2. Push in the Power Supply all the way so that the module is properly seated in the PC Board socket.
3. Secure the Power Supply to the Equipment Shelf using the screw removed in step 2 of paragraph 9.06(A).
4. Plug in the ac power cord. Switch the power on.

9.07 FUNCTIONAL BLOCK DIAGRAM

Figure 9-2 is a functional block diagram of the Power Supply.

Table 9-2. Power Supply Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	a. Remove the -48V Power Supply from the Equipment Shelf (see paragraph 9.06(A).	a. Disconnect -48V power from the Power Supply.	Power Supply faulty.
	b. Connect -48V and ground to the -48V and 48V COM terminals on the Power Supply PC Board. These terminals are located at the rear of the chassis, next to the PC Board connector.	b. Proceed with step 2.	
	c. Measure the dc voltage from the +5V, +15V, and -15V test points to GND.		
2.	a. Check that system power is OFF.	Check for faulty cabling.	Replace the faulty PC Board.
	b. Remove all PC Boards from the Equipment Shelf.		
	c. Install Power Supply in Equipment Shelf (see paragraph 9.06(B).		
	d. Turn on system power.		
	e. Measure dc voltages in turn from the +5V, +15V, and -15V test points to GND while installing the PC Boards (power OFF) in the Equipment Shelf one at a time. Note which PC Board causes the reading to become abnormal.		

Block Diagram

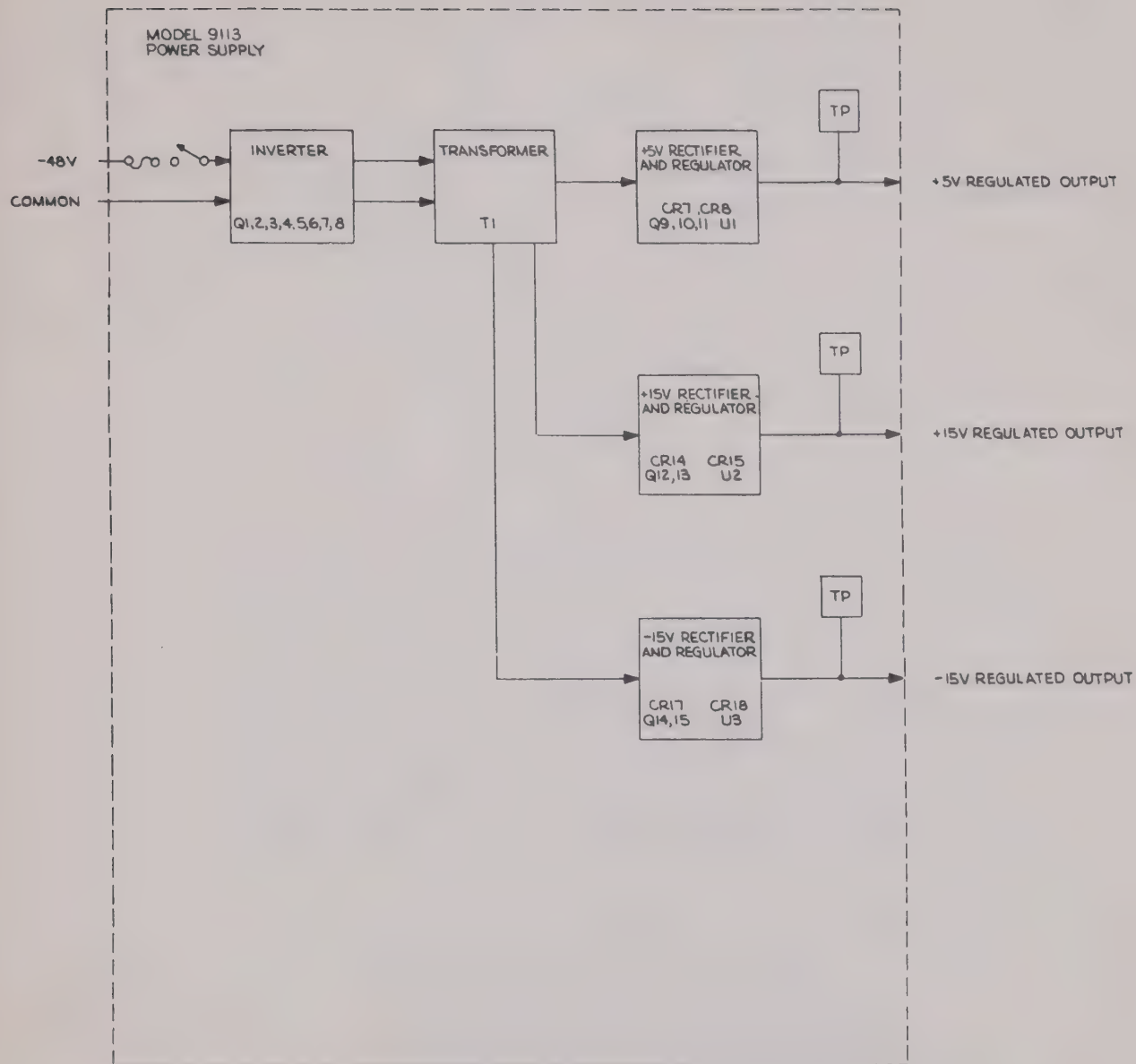
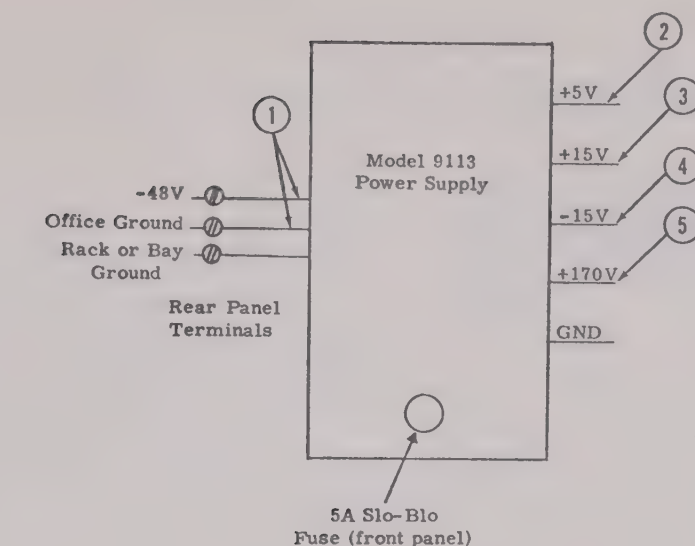


Figure 9-2. Model 9113 Power Supply (-48V), Functional Diagram

-48V DC POWER SUPPLY



TROUBLESHOOTING CHECKS

TEST POINT	READING	REMARKS
①	-48V dc approx.	Office battery voltage: measured from -48V battery to office ground.
②	+5V dc	Measured from +5V test point to GND test point on front panel.
③	+15V dc	Measured from +15V test point to GND.
④	-15V dc	Measured from -15V test point to GND.
⑤	+170V dc	Measured from +170V test point to GND.

NOTES

- A. DO NOT adjust the +5V, +15V, or -15V output adjustments on the front panel of the Power Supply unless a digital voltmeter is available. These voltages must be within a specific tolerance as described in Section IX of the DTMS Operation Manual.
- B. If the Power Supply DC output voltages are not present, first check that the fuse is not open before continuing troubleshooting. Also check that power is available from the source (-48V DC office battery).

Figure 9-3. -48V DC Power Supply
Signal Flow Chart

SECTION X

MODEL 9115 115/230V AC POWER SUPPLY

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10.07	FUNCTIONAL BLOCK DIAGRAM	10-3

However, a "keep alive" low power series regulator transistor is provided in the unit so that it can be tested under no-load conditions when removed from the Equipment Shelf.

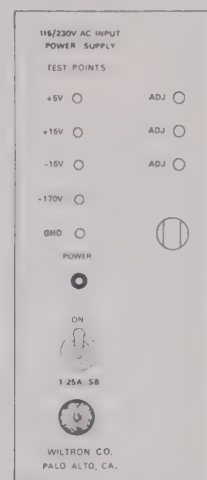


Figure 10-1. Model 9115 Power Supply

10.01 DESCRIPTION

The Model 9115 Power Supply, located at the left side of the Equipment Shelf, provides regulated supply voltages of +5V, +15V and -15V for the Control Panels, Display Modules, and Common Measurement Equipment. A -48V unregulated supply is provided for the pushbutton lamps. A +170V output is also provided but is not used in DTMS systems except for special applications. Power requirements are 115 or 230V AC $\pm 10\%$, 125 watts maximum, 50 to 400 Hz.

The Power Supply consists of a plug-in PC Board with an attached front panel (see Figure 10-1). Mounted on the front panel are a power ON indicator, and a test point and an adjustment control for each of the power supply output voltages. A latch for the Equipment Shelf door is also mounted on the Power Supply front panel. The series regulator transistor for the +5V supply is mounted on the Equipment Shelf PC Board to provide an adequate heat sink.

10.02 OPERATION

Table 10-1 describes the function of the operating controls and indicators on the front panel of the Model 9115 Power Supply. The function of the controls, indicators, and connectors provided for maintenance purposes is described in paragraph 10.03 of this section.

Table 10-1. Operating Controls and Indicators

POWER INDICATOR LAMP: lights when the Power Supply is providing power to the Control Panels, Display Modules, and Common Measurement Equipment.

10.03 PERFORMANCE VERIFICATION/CALIBRATION

The following procedure enables the user to verify that the Power Supply output voltages are within specifications. This check may be

Verification/Calibration
Procedure

PERFORMANCE VERIFICATION/CALIBRATION PROCEDURE

STEP	PROCEDURE
1	Connect the dc voltmeter (Fluke 871A or equivalent) to the -15V TEST and GND test points on the power supply.
2	Turn on the system power and allow the equipment to warm up for approximately 30 minutes.
3	Adjust the dc voltmeter controls as follows: RANGE 100 NULL .1 Digits setting -15.000
4	Check that a meter null is obtained at $-15.000 \pm 75\text{mV}$. If necessary, adjust the -15V ADJ control to obtain a null.
5	Transfer the dc voltmeter to the +15V TEST and GND test points on the power supply.
6	Set the voltmeter digits to +15.000. Check that a meter null is obtained at $+15.00 \pm 75\text{mV}$. If necessary, adjust the +15V ADJ control for a null on the meter.
7	Transfer the dc voltmeter to the +5V TEST and GND test points.
8	Set the voltmeter RANGE control to 10, and the digits to +5.000.
9	Check that a meter null is obtained at $+5.000 \pm 50\text{mV}$. If necessary, adjust the +5V ADJ control for a null.
10	Switch the power OFF at the front of the power supply. Remove the power supply from the Equipment Shelf. Mount the power supply on the extender board (stored behind the Timer), then install the extender board in the slot. Switch the power ON.
11	Connect the dc voltmeter to terminals 14 and 16 (common). Check that the reading is approximately -48V dc.
12	Switch the system power OFF. Remove the power supply from the extender board. Install the power supply in its slot. Switch the system power ON.

performed upon installation of the equipment (prior to use) or when the unit has been repaired or failure is suspected. An accurate dc voltmeter, such as the Fluke 871A or equivalent is required for this check.

10.04 THEORY OF OPERATION

Refer to the power supply functional block diagram, Figure 10-2. The 115 or 230V AC input to the power supply is applied to a step-down transformer through the POWER ON/OFF switch line fuse to the 115/230V select switch. The 115/230V AC switch is set for the input voltage to be used. The ac outputs from the secondary windings are rectified and fed through series regulators to provide dc output voltages of +5V, +15V, -15V, and +170V. The +5V, -15V, and +15V supplies provide power for the Measuring Modules and Control Panels. The +170V output is used for special applications only. The -48V output is unregulated because it is used only for the pushbutton lamps.

10.05 TROUBLESHOOTING

The Power Supply Troubleshooting Chart, Table 10-2, can be used to isolate a fault to a replaceable assembly. The only test equipment required is a dc voltmeter (Simpson 260 or equivalent).

10.06 REMOVAL AND REPLACEMENT INSTRUCTIONS

The following paragraphs provide instructions for removing and replacing the Model 9115 Power Supply. No special tools are required for this procedure.

(A) Removal

Remove the Power Supply from the Equipment Shelf as follows:

1. Set the power switch to the OFF position. Unplug the AC power cord.
2. Remove one screw from the front panel (left side) of the Power Supply.
3. Firmly grasp the handle at the top of the Power Supply and pull it straight out.

(B) Replacement

Replace or re-install the Power Supply in the Equipment Shelf as follows:

1. Line up the Power Supply PC Board with the top and bottom slots in the Equipment Shelf.
2. Push in the Power Supply all the way so that the module is properly seated in the PC Board socket.
3. Secure the Power Supply to the Equipment Shelf using the screw removed in step 2 of paragraph 10.06(A).
4. Plug in the AC power cord. Switch the power ON.

10.07 FUNCTIONAL BLOCK DIAGRAM

Figure 10-2 is a functional block diagram of the Power Supply.

Table 10-2. Power Supply Troubleshooting Chart

<u>STEP</u>	<u>PROCEDURE</u>	<u>ACTION</u>	
		<u>IF INDICATION IS NORMAL</u>	<u>IF INDICATION IS ABNORMAL</u>
1.	Measure the dc voltage from the +5V, +15V, -15V, and +170V test points to GND.	Proceed with step 2.	Power Supply is faulty.
2.	a. Check that system power is OFF. b. Remove all PC Boards from the Equipment Shelf. c. Turn ON system power. d. Measure dc voltages in turn from the +5V, +15V, and -15V test points to GND while installing the PC Boards (power OFF) in the Equipment Shelf one at a time. Note which PC Board causes the reading to become abnormal.	Check for faulty cabling.	Replace the faulty PC Board.

Block Diagram

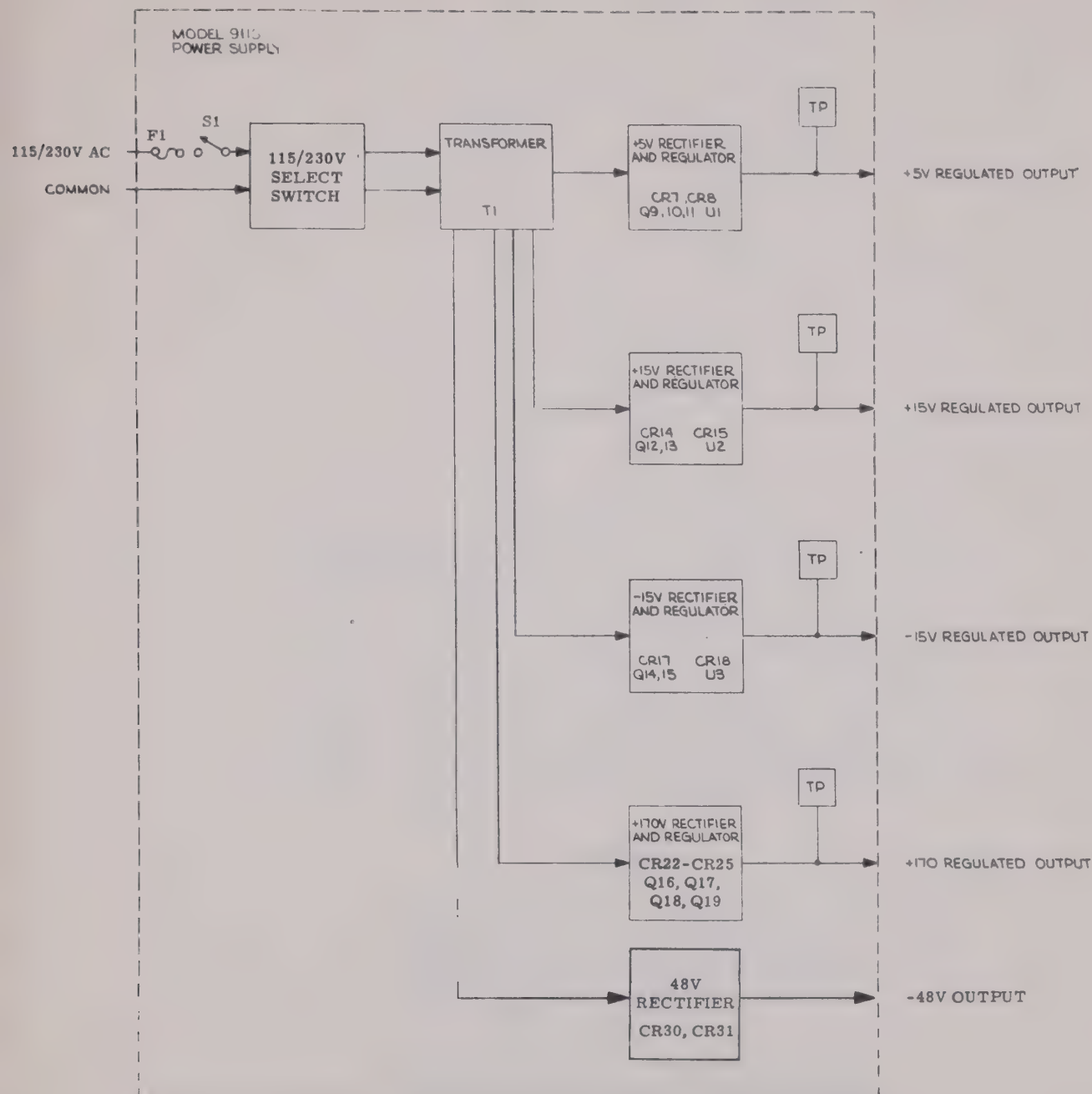
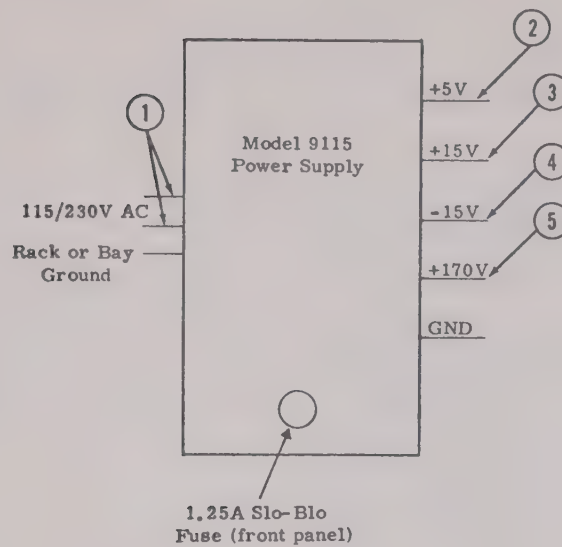


Figure 10-2. Model 9115 Power Supply, Functional Diagram

115/230V AC POWER SUPPLY



TROUBLESHOOTING CHECKS

TEST POINT	READING	REMARKS
①	115V ac (230V ac)	From power source.
②	+5V dc	Measured from +5V test point to GND test point on front panel.
③	+15V dc	Measured from +15V test point to GND.
④	-15V dc	Measured from -15V test point to GND.
⑤	+170V dc	Measured from +170V test point to GND.

NOTES

- A. DO NOT adjust the +5V, +15V, or -15V output adjustments on the front panel of the Power Supply unless a digital voltmeter is available. These voltages must be within a specific tolerance as described in Section X of the DTMS Operation Manual.
- B. If the Power Supply DC output voltages are not present, first check that the fuse is not open before continuing troubleshooting. Also check that power is available from the source (115/230V AC supply).

Figure 10-3. 115/230V AC Power Supply Signal Flow Chart

SECTION XI

MODEL 9340 TEST SELECTOR PANEL

SECTION XI	CONTENTS	PAGE	
11.01	DESCRIPTION	11-1	Holding to permit dialing and holding a circuit or termination for making 2-Wire Level, Noise, or Return Loss measurements.
11.02	OPERATION.....	11-1	
11.03	TROUBLESHOOTING	11-1	Access for measurements is usually made through Western Electric Type 310 jacks on the Test Selector Control Panel. However, if it is desired that more than one measurement function be in use at one time, access can be made directly through the individual Control Panels. When test access is made at a particular Control Panel, that test function selection is inhibited at the Test Selector Panel.
11.04	REMOVAL AND REPLACEMENT	11-1	
11.01	DESCRIPTION		
	The Model 9340 Test Selector Panel provides a single test access point for Level/Noise, Frequency, Send Oscillator, 2-Wire/4-Wire Echo Return Loss and Singing Point, and Multimeter Cable Analyzer when used in conjunction with the following WILTRON Control Panels:		
	Model 9301, 9304, or 9306 Level/Noise Control Panel		
	Model 9320 or 9321 Oscillator Control Panel		
	Model 9310 Return Loss Control Panel (4-Wire/2-Wire)		
	Model 9311 Return Loss Control Panel (2-Wire)		
	Model 9370 Multimeter Cable Analyzer Control Panel		
	Each measurement function is selected by a pushbutton back-lighted switch. Provision is also made for Talk/Dial and		
11.02	OPERATION		Table 11-1 lists the functions of the controls and connectors on the Model 9340 Test Selector Control Panel.
11.03	TROUBLESHOOTING		The Model 9340 Test Selector Panel can be checked using the procedure in Table 11-2, with the system power OFF. If continuity is not measured as indicated, the particular switch or associated wiring is faulty.
11.04	REMOVAL AND REPLACEMENT		Table 11-3 contains instructions for removing or replacing the PC Board inside the Test Selector Panel.

Table 11-1. Function of Test Selector Panel Controls and Connectors

CONTROL OR CONNECTOR	FUNCTION
<u>Mode Group</u>	
RLS	Releases the connections to all of the Control Panels from the circuit under test.
TALK/DIAL 2W	Connects the dial handset (connected to rear panel wirewrap pins 14 and 15) to the circuit under test through the 2W SEND/RCV jack so that a connection can be established.
SEND/RCV (NORMAL)	Connects the selected measurement function to the Test Selector Panel test jacks. Also connects a holding coil across the circuit under test when the 2-Wire Level/Noise or Oscillator function is selected.
<u>Function Group</u>	
OSC SELF CHECK	Momentary pushbutton used to check the output Level and Frequency of the Oscillator Control Panel, which is shown on the Level/Noise and Frequency Displays. When pressed, the pushbutton disconnects the test circuit from the Oscillator and Level/Noise Control Panels. However, if circuit holding is being used, the holding coil remains connected to maintain the test connection.
OSC SEND 2W	Connects the output of the Oscillator Control Panel to the 2W SEND/RCV jack.
LEVEL/NOISE 2W	Connects a 2-Wire circuit under test to the input of the Level/Noise Control Panel (through the 2W SEND/RCV jack).
OSC L/N 4W	Connects the transmit (send) side of the circuit under test to the output of the Oscillator Control Panel, and the receive side to the input of the Level/Noise Control Panel. Used in conjunction with the 4W SEND and 4W RCV jacks.
RET LOSS	Connects the circuit under test to the input of the Model 9311 Return Loss Control Panel for 2-Wire or 4-Wire Return Loss measurements. See Section V(A) for operating instructions.
MCA 2W	Connects a 2-wire circuit under test to the input of the Multimeter Cable Analyzer Control Panel.

Table 11-1. Function of Test Selector Panel Controls and Connectors (cont'd.)

CONTROL OR CONNECTOR	FUNCTION
<u>Connectors</u>	
4W SEND	Western Electric Type 310 jack, used for transmit (send) connections for 4-wire measurements with the Oscillator or Return Loss functions.
4W RCV, 2W SEND/RCV	Western Electric Type 310 jack, used for receive connections for 4-Wire measurements with Level/Noise or Return Loss functions, or for send/receive for 2-Wire measurements (Level/Noise or Oscillator functions).

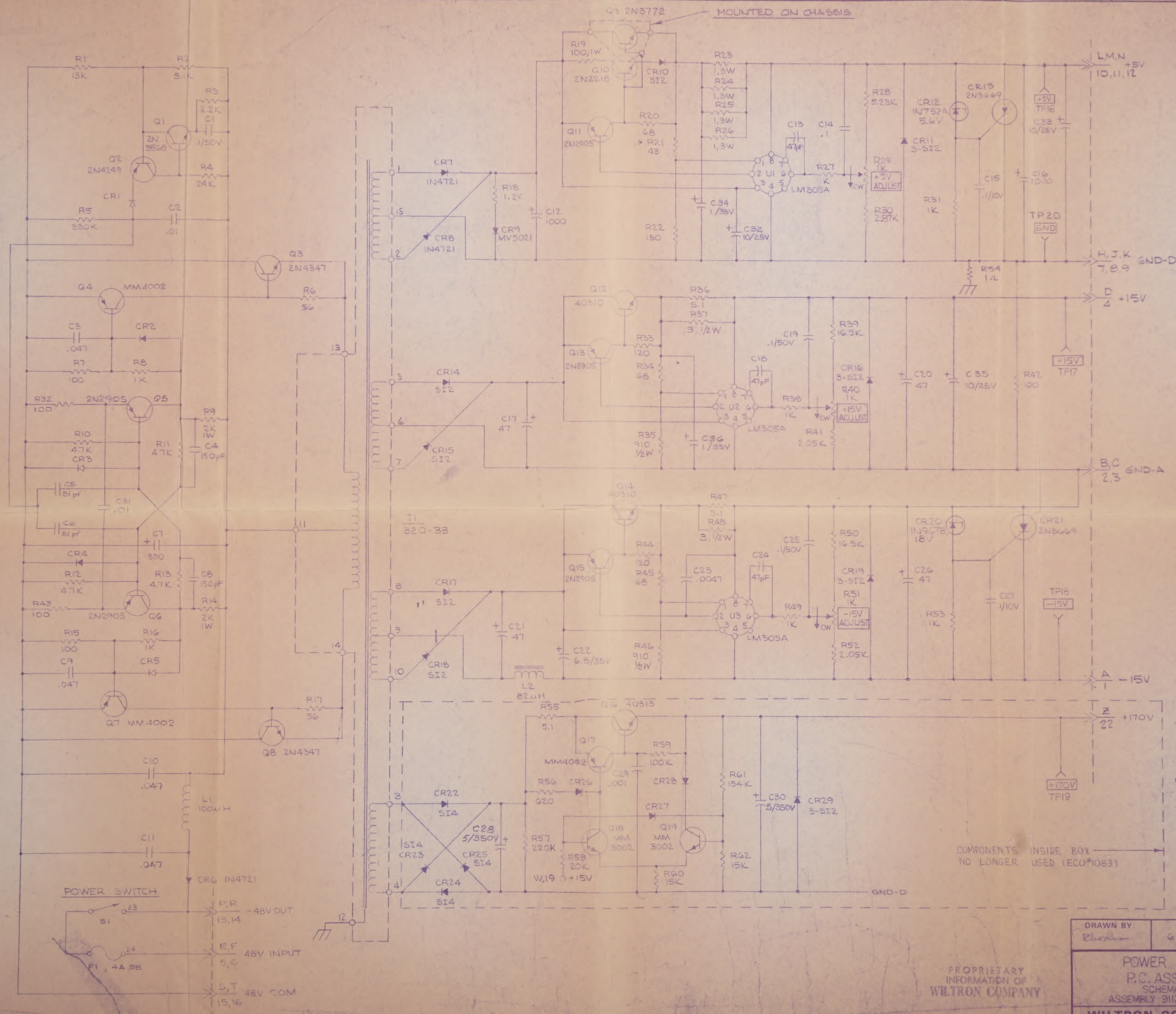
Table 11-2. Model 9340 Test Selector Panel Continuity Checks

SWITCH(ES) SELECTED	CHECK FOR CONTINUITY BETWEEN REAR PANEL PINS
TALK/DIAL 2W	14 and 12, 15 and 13 without plug in 2W SEND/RCV jack.
OSC SELF-CHECK	E and L, F and M
OSC SEND 2W and SEND RCV (NORMAL)	E and 12, F and 13
LEVEL/NOISE 2W and SEND RCV (NORMAL)	L and 12, M and 13
OSC L/N 4W and SEND RCV (NORMAL)	E and 10, F and 9, L and 12, M and 13
RET LOSS and SEND RCV (NORMAL)	H and 10, J and 9, P and 12, N and 13
MCA and SEND RCV (NORMAL)	C and 12, D and 13
NONE	K and R, K and S (measure resistance of hold coil)

Table 11-3. PC Board Removal and Replacement

STEP	PROCEDURE
1	Remove the four screws from the cover of the Test Selector Panel. Remove the cover by pulling it straight back to detach the cover from the PC Board connector inside the Control Panel.
2	Remove the screw that secures each jack (TRMT and RCV) to the front panel.
3	Remove the PC Board from the Control Panel. The two jacks and switches are hardwired to the PC Board.
4	Install the new PC Board in the Control Panel so that the switches extend through the front panel.
5	Secure the TRMT and RCV jacks to the front panel using one screw each.
6	Install the cover on the Control Panel so that the PC Board connector mates properly with the cover socket and then secure it with four screws.

REV	C.O. NO.	DATE	BY
B	1077	2-9-77	
C	-	4-26-78	
D	-	5-15-78	
E	1434	5-26-78	
F	3037	8-13-84	



REFERENCE DESIGNATORS	
LAST USED	NOT USED
R62, C36, Q19, CR29, U3, L2, T1	TP1 THRU TP15

NOTE: UNLESS OTHERWISE SPECIFIED,
 1. ALL RESISTOR VALUES IN OHMS.
 2. ALL CAPACITOR VALUES IN MICROFARADS.
 3. ALL DIODES ARE IN4446.
 4. DENOTES PANEL MARKING.
 5. DENOTES POTENTIOMETER SYMBOL.
 6. INDICATES CLOCKWISE ROTATION.
 7. DENOTES GND CHASSIS.

DRAWN BY: R. H. H.	DATE: 6-14-73	CHECKED BY: L. H. H.	APPD. BY: P. H. H.
POWER SUPPLY P.C. ASSEMBLY SCHEMATIC ASSEMBLY 9113-L-230-3			
WILTRON COMPANY PALO ALTO, CALIFORNIA		DWG SIZE D	SHEET 1 OF 1

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